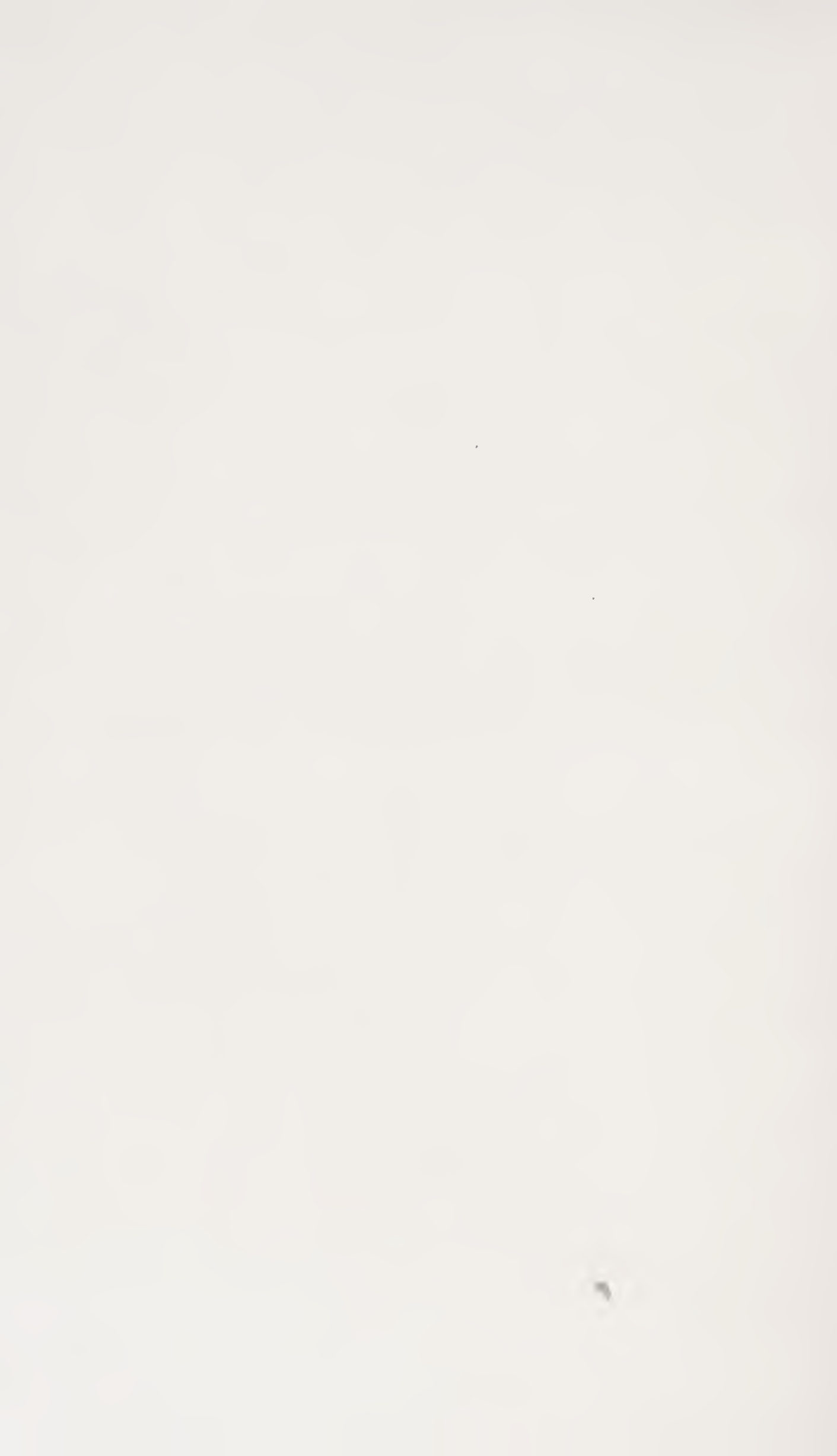


Scientific + temper

G. T. Narayana Rao



SCIENTIFIC TEMPER



G. T. Narayana Rao

1997

Athree Book Centre Mangalore

SCIENTIFIC TEMPER in English

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Published by G. N. Ashokavardhana
(for Athree Book Centre)

Typeset and printed at Sri Shakti Electric Press
Jayanagara, Mysore 570 014 (Phone 0821-22775)

Pages 120

Price Rs 15

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Pensive Man on the title page : Courtesy Navakarnataka
Publications (P) Ltd

Trade enquires
Athree Book Centre, 4 Sharavathi Building
Balmatta, Manglore 575 001 (Phone 0824-425161)

In Search of Light

It's no exaggeration to say that G. T. Narayana Rao has done yeoman service to Kannada in popularising science writing in the language. It's a veritable 'windfall' that he has benefited the community at large by writing this small but beautiful book in English, which holds in a nutshell everything we needed to know on this most ticklish topic called *Scientific Temper*. Since he's very clear about his target audience GTN does not seem to be under any pressure to pander to the specialists whose habitual abode is somewhere beyond the biosphere.

GTN has distributed his argument among eighteen compact and petite chapters giving each chapter an appropriate title so that the main focus is not lost sight of. But it becomes evident at once that he has an uncanny knack of accommodating his gleanings from poets, philosophers, thinkers and scientists of East and West thereby reflecting the craft of a comprehensive mind. There is an unmistakable attempt to overcome the soul-killing compartmentalisation by bringing on a common platform savants belonging to different times and climes.

Since the central idea is the scientific temper, the author traces quickly in the initial chapters the uniqueness of man, man as a social animal, his psyche, he as an emotional being, values in life, etc. The attainment of intrinsic worth and moral standards by an individual are emphasised so that he may not live aloof from the rest of the society but he realises the essential goal of life. Changing Keatsian terms a bit GTN arrives at a liberating formula: "Duty is God, God duty—that is all ye know on earth, and all ye need to know," because "honest purposeful work makes a heaven of a hell." If religion comes in the way of achieving this, as it's increasingly made dogmatic by the vested interests, then one must steer clear of such a religion; if Scriptures advocate things which are antithetical to the human spirit, "then Scriptures need amending" as the Buddha said long ago.

The author rightly comes down very heavily on the pseudo-science called astrology that masquerades as a legitimate clone of astronomy. The evils of superstition along with astrology hold our society in a double-bind and an all-out effort is a must to fight these twin curses that are eating into the very vitals of our society.

The underlying message is that, it's time one realised that "life is larger than authority and religion ; the head and heart should act as complementary essentials of a good life ; the spirit of enquiry is an inextinguishable fire that burns the dross of ignorance ; in understanding the mysterious harmony of nature, the scientist does not particularly look for its utilitarian value ; he studies nature because he delights in it."

Reading between the lines one is enriched by the truth that the scientific pursuit is more than what an anaemic altruism could achieve. Science connects conduct and wisdom. Any attempt to view them separately is not only defective but prone to be dangerous. The book ends appropriately invoking Vivekananda's words, he being an unfailing beacon and the sturdy bastion of rationality. After all the *summum bonum* of life is to "achieve liberty breaking all bondage to become conscious of the innate grandeur". *Scientific Temper* aims at achieving this not merely at the individual level but at the societal level.

I feel humble beyond description for this opportunity to write a few words on this work which is sure to exercise the minds of the readers. May the indefatigable pen of this venerable Professor write on so that the grateful society acknowledges its gratitude in full measure.

C. Naganna
Professor of English
Maharaja's College, Mysore

Throwing Light on Life

This book of G. T. Narayana Rao is about science. It steers clear of two possible pitfalls. The presentation of scientific ideas is not at all dry. Nor does the book slip into unnecessary and unwanted digression. The author always stays focussed on the topic under discussion. His book makes a lively and fascinating reading. He draws on myths, poetry, religious texts, epics and fables to illustrate his ideas. These illustrations illuminate the scientific concepts and give them a literary flavour. Tracing the growth of science, the book also offers us an insight into the lives of renowned scientists like Einstein and Chandrasekhar.

Rao is very scientific while writing about science. He defines the terms that he uses and leaves nothing unexplained. Therefore there is no ambiguity at all. There are many allusions to physics, mathematics and astronomy. The fact that there are no references to natural sciences only shows that the author does not write about things of which he is not the master. However one feels that his strident criticism of irrationality could have been tempered with wit and humour. On the whole the book is the voice of sanity amid irrational influences that threaten to overwhelm us. What a better place the world would be if science comes out of the laboratory and guides human life! This is precisely the dream of Narayana Rao and one can hardly blame him if he wants to see his dreams translated into realities.

M. Shankaranarayana Bhat
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College, Kollegal

Author's Note

V*aijnanika Manodharma*, my Kannada book on scientific temper, was published by Navakarnataka Publications Pvt Limited in 1990. Till 1996 it has seen four editions. The prime motivators of that work were Mr B.V. Kakkillaya, Mr R. S. Rajaram and the late Mr S. R. Bhat. Mr Prabhanand Attavar, who insists he was my student in the College during the 1950s, has been repeatedly haranguing me that I should bring out an English version of the same book. *Scientific Temper* is *not* a translation of the Kannada book but an originally conceived and executed work. I dedicate this book to these four friendly influences—they are the very embodiments of scientific temper.

Prof S. Ramaseshan, Emertius Professor, Raman Research Institute has helped this endeavour “as a token appreciation for your efforts” [to spread scientific temper among people for the joy of it—no financial considerations for the author or the publisher] with a handsome donation from Dr C. V. Raman Memorial Trust. A few other friends have also contributed (see page 111 for details).

Two Professors of English M. Shankaranarayana Bhat and C. Naganna have lovingly vetted the text, set its stylistic tone and thrown additional light on the subject.

Natyacharya K. Muralidhara Rao has designed the front cover. The corners of the triangle in the background represent *authority, religion and science*

As usual Mr R. V. Sreenivasa Murthy and Mr R. S. Mohan Murthy of Sri Shakti Electric Press have made this book also ‘a thing of beauty.’ Kumari Devika has typeset the script. My daughter-in-law Mrs Rukmini Mala has assisted me in the preparation of the Index.

Thank you all !

Nehru Birthday 1997
Mysore

G. T. Narayana Rao

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THE WISDOM OF THE CENSUS

*Our I's are ever the greatest impediments
to our vision ;*

*Our years often the impairers of our
hearing ;*

*Our no's sometimes the decoys from our
scenting the paths of wisdom ; and—*

*Our tong(ue)s, the means to spread fire
among the combustibles.*

Prof K. N. Iyengar

Scientific Temper

1. Uniqueness of Man

Man is a thinking, speaking, inventing and communicating animal. Additionally he has the memory power. He can recall past experience at will, and put it to use at the present moment. These faculties and facilities are together termed *intelligence*. No other animal is endowed with this facility. Animals act by instinct.

If nature had a purpose in placing man atop the evolution-ladder, it is that, he should live in harmony with his environment like other living beings. A child of nature, he is neither its master nor mentor. In the ever active evolution-experiment he is but a link, an important one at that. Therefore he too has to undergo the birth-growth-development-decay-death cycle leaving successive generations to play their roles in the grand design of Mother Nature.

“There is no free lunch in nature” is an old adage. “Nothing comes out of nothing” (Shakespeare). These are euphemisms for “food sprouts not from vacuum.” True, one cannot produce something out of nothing, but one can ‘create’ (read invent or construct) something out of something else by investing the appropriate skill, labour and material in accordance with a plan. This would require man to work with a purpose and derive joy from it. Any deviation from this strict unwritten dictum of nature is bound to boomerang.

What is the purpose of human life ? Or, what is the motto set by nature for man ? The real answer is “Live in harmony with your fellow human beings, plants and animals, and inanimate things too, and explore your potential fully.” Nature provides ample scope for

such peaceful co-existence and co-development. The dynamic calmness of a dense deep forest, the river-ocean symbiosis, or the joy the starry heavens radiate do all sing the same refrain : live and let live, give and forgive, strive and thrive—all in company. Man can as well sing nature's benevolence with Rabindranath Tagore : "Thou hast made me endless, such is thy pleasure."

2. Man, a Social Animal

A human child is born of human parents only. All exceptions to this fundamental law of nature are but fanciful imaginations of an innovative mind.

Now, the parents instinctively *feel* for their progeny. Call it love, kindness, concern, anxiety, duty or responsibility the child gets it, or a proportionate mixture of these human feelings, in ample measure. Such a nature-infused parent-child relationship gradually coalesces into a man-generated force, which we will call *authority*. It has nothing to do with the forces of nature.

The child is the privileged 'property' of its parents. True. But it belongs to the society also. A society is variously described as a "group of animals or plants living together under the same environment and regarded as constituting a homogeneous unit or entity; especially a group of persons regarded as forming a single community" or "an enduring and co-operative social group whose members have developed organized patterns of relationships through interaction with one another" (*Webster*).

The important point here is : society has *authority* over the individuals constituting it, and individuals get *protection* from the society. Broadly speaking a

nation is a blend of societies (in the present parlance, *States*) spread over a geographically contiguous area. It is “a stable, historically developed community of people with a territory, economic life, distinctive culture and language in common” (*Webster*).

Thus, the ultimate authority for an individual is the nation or its lawfully constituted Government. By a process of historical evolution, different nations have different forms of Government, each deriving its legitimacy from a written constitution or a set of well-established conventions. Whatever be the case, call it democracy, theocracy, autocracy, or any other -cracy, the authority of a nation over its people is a *subjective* force. That is to say, authority between parents and children, society and civilians, institutions and employees or nation and people is a man-generated force unlike gravitation, atmospheric pressure, radiation etc., which are natural forces. Man is an infinitesimally small product and part of nature. He has no control over it or its forces. The only course open to him is to tune his life to nature's music.

Just consider an earth divested of human beings but abounding in plants and animals. In this imaginary set-up, authority would surely lose its *locus standi*. Nature, the supreme authority, does not recognize the human authority !

3. Man has a Psyche

Psyche is the mind “considered as an organic system reaching all parts of the body and serving to adjust the total organism to the needs or demands of the environment” (*Webster*). Thoughts are flashes of ideas in the mind, maybe selfgenerated or environment-induced. Stored experience in the mind

is the launching pad. Ultimately it is nature that acts as the stimulus to which the human response is thought.

Stand atop a hill on a clear moonless night and survey the entire firmament. You don't have to know astronomy to enjoy the celestial grandeur just as you don't have to learn cookery to relish a culinary delicacy. First, you are simply astounded by the stupendousness of the canopy. "How I wonder what you are!" As you continue with the hobby of star-gazing, you begin recognizing the stellar patterns studding the 'ceiling' above the earth. Slowly it dawns upon you that the celestial sphere rotates around *you* as its centre !

There is order in the sky. The sun, moon, planets and stars exhibit a continuous east-west march-past or ceremonial parade. The VIP here is, of course, *you* the observer. Every person at every point of the globe *feels* he is at the centre of the universe. However astronomy tells us that neither any individual, nor a 'chosen' city, nor even the earth has this privileged status. In fact the universe has no centre at all. "No planet, or star, or galaxy can be typical, because the cosmos is mostly empty. The only typical place is within the vast, cold, universal vacuum, the everlasting night of intergalactic space, a place so strange and desolate that by comparison, planets and stars and galaxies seem achingly rare and lovely" (Carl Sagan).

An intelligent and curious mind imbibing the spirit of the heavens falls into a deep reverie. Here physique stops and mysticism spurs the human imagination. The following few poetic or mystic effulgences are to be understood in this light.

The Rigvedic rishis 'inebriated' by the celestial nectar sang His glory :

*devasya pasya kāvyam
namamāra najeeryati*

Behold the Epic of God : it knows neither death nor old age.

Such an excited mind hums the hymn : “Have I not drunk of the Soma ? In Heaven is one-half of me. Down below I have drawn the other” (Lin Yutang in *The Wisdom of India*).

Not so, for a ‘secular’—not God-possessed—anonymous poet, writing over a goblet of wine :

Whoever would search the starry sky,
Its secrets to divine, sir !
Should take his glass—I mean, should try
A glass or two of wine, sir !

Ed. Augustus De Morgan in *The World of Mathematics*

However the deeply religious thinkers saw the unfolding mystery differently : “And God said, Let there be a firmament in the midst of the waters and let it divide waters from the waters . . . And God called the firmament Heaven” (*Genesis*).

The twelfth century astronomer-poet Omar Khayyam’s imagery on the eclipse is replete with metaphors :

For in and out, above, about, below,
’Tis nothing but a magic shadow-show,
Play’d in a Box whose candle is the Sun,
Round which we phantom figures come and go.

Rubaiyat

Nearer our times poet Rabindranath Tagore (1861-1941) has glorified God’s benevolence in mystical thoughts couched in musical idioms : “I know not from what distant time thou art ever coming nearer to meet me. Thy sun and stars can never keep thee hidden from me for aye” (*Gitanjali*).

The philosopher-poet. D. V. Gundappa (1887-1975)

has visualized the oneness of the spirit that pervades the universe :

Has the cosmic spirit flowed down from beyond the blue
And embodied itself in the spirit of self ?
Or has the spirit flowed out from the centre of self
And spread beyond the sky ? Mankuthimma

Thus Sang Mankuthimma—Tr. A. Narasimha Bhat

The above examples are but random samples of the experience mankind has gained and accumulated in the past. Interaction between human intellect and cosmic unfathomability, and so mystery, generates cosmic religious feelings. They are human emotions, and like love, hatred, kindness, cruelty etc., are subjective, i.e., they have no relevance in nature.

Man's experience of life has imprinted on his psyche an indelible mark: authority and order are inseparable. The former is the controller, the latter the controlled. Absence of authority is chaos. Project this authority-order complementarity imprint on the sky. What do you observe ?

There is order everywhere, every time. Absolutely no chaos anywhere, any time. How is it possible? The human intellect reasons it out and perceives the presence of an all-pervading superior authority directing the celestial mechanics. Man realizes further that the activities here, down on the earth, are directly linked to those there, up above in the sky. In fact, he thinks, the former are controlled by the latter. And therefore, he concludes, there is a superior authority, intelligence or force presiding over the destinies of all.

Where does *it* reside ? What is *its* form ? The search for the mysterious and elusive *it* took several routes, all in the abstract plane, of speculation, without yielding any concrete results. *It* is there, yet *it* is not

there. Such a relentless pursuit, however, resulted in the birth, growth, development and various ramifications of philosophy, the mother of all religions, humanities and sciences.

Philosophy is “a study of the process governing thought and conduct ; theory or investigation of the principles or laws that regulate the universe and underlie all knowledge and reality, included in the study are aesthetics, ethics, logic, metaphysics, etc” (*Webster*).

4. Man, an Emotional Being

Interaction with fellow beings, called the social intercourse, and the stimulus from nature generate emotion in man. It is a “strong generalized feeling ; psychical excitement” (*Webster*). Emotion may be beneficial or positive, harmful or negative, or just indifferent or neutral. No absolute division is possible. while a mother’s love for her child is a beneficent emotion, that of Putani in the guise of a benevolent mother to Krishna is certainly harmful. Rage or anger is generally considered destructive. Not so when Bhima took his vow to crush Duryodhana’s thighs.

Ultimately it is the *intention* that is the real determinant of the quality of the emotion. It is here, in nurturing noble intentions and thwarting ignoble ones, that philosophy has a decisive role to play. To be specific, it is the religious facet of philosophy that strives to reform the individual’s intention, so also of the society’s, and thus helps to maintain a healthy balance between various emotions.

What is religion ? It is “the belief in a divine or a superhuman power or powers to be obeyed and wor-

shipped as creator(s) and ruler(s) of the universe” (*Webster*). This “belief in a divine or superhuman power,” metaphorically speaking, manifests itself in various modes depending upon the psychic fabric of the individuals. One can discern here three broad categories : (i) surrender to the omnipotent and omniscient God ; (ii) obeisance to reason ; (iii) faith in nature. These categories are not necessarily mutually exclusive : the same person may display anyone or more of them according to his understanding of the situation.

Generally speaking, people belonging to the first category are called the believers, the second the rationalists, and the third the scientists. Believers are theists. Theism is “belief in the existence of a god or gods” and setting one’s life accordingly. Rationalism is “the principle or practice of accepting reason as the only authority in determining one’s opinion or course of action,” and scientism is “the principle that scientific methods can be and should be applied in all fields of investigation” (*Webster*).

Now , morality is “the character of being in accord with the principles or standards of right conduct,” and ethics “the study of standards of conduct and moral judgment” (*Webster*). It is therefore clear that in the ultimate analysis, whatever be the mode of approach, the goal of theists, rationalists and scientists should converge on a good, morally sound and socially purposeful life. Such a life alone can keep the intention noble, harness the emotions to the right track and make life truly beautiful. “A thing of beauty is a joy for ever” (Keats).

5. Values in Life

Value in life is “that which is desirable or worthy of esteem for its own sake ; thing or quality having intrinsic worth” (*Webster*). Values emerge in the social dynamics of a vibrant nation: individual episodes invariably pointing at certain fundamental truths of life. For example:

Satyam vada dharmam chara : speak the truth and act strictly in accordance with the moral code.

Dayeye dharmada moola : compassion is the root of moral conduct. '

Dharma, artha, kāma, moksha, called the *chaturvidha purushārthas*, are the key to a good life. *Dharma* is conduct in accordance with moral principles ; *acquisition of fortune in accordance with dharma* is *artha* ; so also is the fulfilment of *kāma*, the desire ; in this way, i.e., the righteous way, one should attain *moksha*, the salvation (happiness).

Honour thy father and thy mother. Thou shalt not kill. Thou shalt not commit adultery. Thou shalt not steal (*Bible*).

Save those who persevere and do good works. Theirs will be forgiveness and a great reward (*Quran*).

Do thy duty, aspire not for the fruit thereon (*Gita*).

The epics of all nations depict these values couched in stories, anecdotes, metaphors and poetic imagery. T. R. Venkatarama Sastri in his *Foreword to Lectures on the Rāmāyana* by V. S. Srinivasa Sastri writes :

Having ventured to call these discourses pious, I am reminded of the hurt they caused to some devout persons by their professed object of presenting Sri Rama in a purely human aspect, ignoring his place among the great Avatars or incarnations. I hope I shall not be deemed to be repeating the offence by putting the question whether there is nothing to be gained

by studying the Epic as a human document rather than religious textbook. The author of the *Ramayana* puts in the mouth of his Divine Hero the words *atmanam manusham manye*, suggesting that according to himself his conduct was that of a human being desirous of acting conformably to the highest ideals of *dharma* or the best traditions of his time. His example is of value to common men, not to be put aside as that of one who stood on a plane all his own and to be judged by other than human standards. The lessons of his life are available as much to those who do not accept his divinity as to those who accept him as such.

The foregoing explanation of *Ramayana* shows how a value or stature gained by leading a morally sound life and facing all tribulations and privations can be universal. Whether a value or a set of values is divine or *avatār* is better left to the belief and judgement of the individuals concerned. So long a person in his private life and public conduct follows strict moral standards, irrespective of the source from which he derives his strength of conviction, society considers him a righteous person. He is a man of character. Now, a theist may perceive value as of divine origin, while a rationalist or scientist may understand it as an essential code of conduct for good human relations and internal equilibrium and mental composure. In all cases : value sets the goal for the individual to strive and attain.

Value in action is character. Said Martin Luther (1483-1546) : "The prosperity of a country depends, not on the abundance of its revenues, nor on the strength of its fortifications, nor on the beauty of its public buildings, but it consists in the number of its cultivated citizens, in its men of education, enlightenment and character ; here are to be found its true interest, its chief strength, its real power." The Indian sages sang long ago *sheelam sarvasya bhushanam*.

Religion in its deepest perspective and broadest application is but the repository of the values the human race has painfully learnt over the aeons. However in actual practice—daily life or intercourse with the society—it assumes different forms depending upon local conditions. Here geography (conditions of the landscape) and history (virility of the inhabitants) together play decisive roles. That is why we have so many religions scattered all over the globe. What rivers are for geology so religions are for psyche.

The river-religion simile is apt at least for three reasons : (i) A river absorbs and assimilates all influxes pouring into it; so does a religion. (ii) A river is verily the *vis vitae* (life force) in action. Religion acts precisely so in the psychic plane. (iii) River valleys are cradles of civilizations. And religions are crucibles metamorphosing civilizations into cultures.

6. God ?

The primitive man was mortally afraid of the forces of nature. Wild animals were menacingly frightening. While his modern counterpart knows the reasons for this fear, the primitive man did not. He felt the environment was hostile, and 'saw' in it the working of the invisible hand of a superpower. You cannot fight it and establish your stand unless you wish to be annihilated. Perhaps you can surrender yourself at its altar, offer it ritualistic sacrifices, praise its *nigraha-anugraha sāmāthyā* and win its grace. That would ensure you protection from inimical elements. Thus one sees fear at the base of the earlier concepts about God. And so the primitive Gods are invariably the personifications, if not the incarnations, of the wild forces of nature, ferocious animals etc.

The gradual evolution of the human society gave birth to recognizable patterns of behaviour in family life. Tribes jumbled up in various habitable places. The powerful person in each tribe became its leader. He, as the protector and saviour of the tribe, was looked upon as the human incarnation of the Almighty God: *rājā pratyaksha devata*. The leader served as an effective link between the invisible God and the people. God communicated with them through their chosen leader.

Thus came into circulation the concept of a super-human God. The 'superpower' of the primitive days shifted to the 'superhuman' of the organized society. This 'personal God' (God in human form) endowed with omniscience and omnipotence is the Creator (Brahma), Protector (Vishnu) and Destroyer (Maheshwara).

The *Holy Bible* puts it thus : "In the beginning God created the heaven and the earth. And the earth was without form, and void, and darkness *was* upon the face of the deep. And the spirit of God moved upon the face of the waters. And God said, let there be light : and there was light . . . And God said, let us make man in our image, after our likeness . . . So God created man in his *own* image, in the image of God created he him ; male and female created he them."

The *Glorious Quran* says : "O mankind ! Worship your Lord, who hath created you and those before you, so that ye may ward off (evil). Who hath appointed the earth a resting place for you, and the sky a canopy; and causeth water to pour down from the sky, thereby producing fruits as food for you."

Hymn of Creation in Rigveda (translation by A. A MacDonnell) reads thus :

Nonbeing then existed not nor being :
 There was no air, nor sky that is beyond it.
 What was concealed ? Wherein ? In where protection ?
 And was there deep unfathomable water ?

.....

None knoweth whence creation has arisen ;
 And whether he has or has not produced it :
 He who surveys it in the highest heaven,
 He only knows, or haply he may know not.

Manduka Upanishad says : “He on whom the sky, the earth and the atmosphere are woven, and the wind, together with all life breaths, Him alone know as the one Soul.”

And *Brihad-Aranyaka Upanishad* explains: “Where there is duality, as it were, there one sees another ; there one smells another ; there one tastes another . . . But where everything has become just one’s own self, then whereby and whom would one see? Then whereby and whom would one smell ? Then whereby and whom would one taste ?” (quoted from *The World of Physics*).

The unknown, unknowable yet according to man’s ego the knowable, or the abstract had to be visualized. It was a dire psychological need, to establish the cause-effect relationship between the known physical universe (effect) and its cause. So comes the Creator as the creation of the human mind.

One can discern the same basic refrain—i.e., the earth with all its rich potential, the star-studded heavens, the beauty that pervades the whole cosmos etc., are but creations of God who has gifted them to man—in all the scriptures all over the globe. Yet one has to read them not as physical facts but as fascinating poetic imageries painted on the canvas of life with the brush of imagination and ink of experience. They are creations of a curious and creative mind

struggling to comprehend the incomprehensible.

Why the need for inventing the elusive God and make Him responsible for all the things one experiences in life ? As explained earlier it is a psychological need for man to contain the irrepressible emotions, especially the baser ones. Reason, experiment or observation do not fill this gap. Questions like—why is there a universe ? on what does it rest ? did it have a beginning ? will it have an end ? who created it ?—though arising out of a continuous scientific study of nature, do not get an immediate answer. The human ego or pride is not ready to wait or proceed in a systematic manner hoping to get the answer in the foreseeable future. Result ? Shifting the responsibility to God, explaining away every question by a reference to “ancient” treatises, the holy scriptures, and resorting to unlimited verbal jugglery. When an irreconcilable situation is reached, recourse to brutal force to still the voice of dissidence is not uncommon. However such a temporary “victory” cannot annihilate the spirit of inquiry which is a natural feature of the human intellect.

The simple fact is : no one at no time can possess or get all the answers, nor does one need to possess them either. Because that is not the purpose of nature in evolving the human species and equipping it with intelligence. Consider the following two analyses made by two of the greatest thinkers of the past.

Roman statesman Seneca (1st century AD) in *Natural Questions* (as quoted by Carl Sagan in *Cosmos*) :

The time will come when diligent research over long periods will bring to light things which now lie hidden. A single lifetime, even though entirely devoted to the sky, would not be enough for the investigation of so vast a subject . . . And this knowledge will

be unfolded only through long successive ages. There will come a time when our descendants will be amazed that we did not know things that are so plain to them . . . many discoveries are reserved for ages still to come, when memory of us will have been effaced. Our universe is a sorry little affair unless it has in it something for every age to investigate. . . . Nature does not reveal her mysteries once and for all.

Albert Einstein (1879-1955) and Leopold Infeld (1898-1968) write in *The Evolution of Physics* :

In imagination there exists the perfect mystery story. Such a story presents all the essential clues, and compels us to form our own theory of the case. If we follow the plot carefully we arrive at the complete solution for ourselves just before the author's disclosure at the end . . . it appears at the very moment we expect it . . . This great mystery story is still unsolved. We cannot even be sure that it has a final solution. The reading has already given us much ; it has taught us the rudiments of the language of nature; it has enabled us to understand many of the clues, and has been a source of joy and excitement in the often painful advance of science . . . attempts to read the great mystery story are as old as human thought itself.

Thus for a rationalist and a scientist the need for God does not arise at all. He may employ the word as a metaphor for nature. Read what Einstein has written on several occasions :

1915. "Why do you write to me. 'God should punish the English ?' I have no connection to either one or the other. I see only with deep regret that God punishes so many of his children for their numerous stupidities, for which he himself can be held responsible ; in my opinion, only his nonexistence could help him."

1927. "I cannot conceive of a personal God who would directly influence the actions of individuals... My religiosity consists in a humble admiration of the infinitely superior spirit that reveals itself in the little that we can comprehend of reality."

Swami Vivekananda (1863-1902) explains the Impersonal God concept thus :

And indeed we shall be fools if we go to the Father of all mercy, Father of all love, for trivial earthly things. Unto him, therefore, we shall go for light, for strength, for love but so long as there is weakness and a craving for a servile dependence in us, there will be these little prayers and ideas of the worship of the Personal God. But those who are highly advanced do not care for such little helps, they have well nigh forgotten all about this seeking things for themselves. The predominant idea in them is—not I, but thou, my brother. Those are fit persons to worship the Impersonal God. And what is the worship of the Impersonal God? No slavery there—“O Lord, I am nothing, have mercy on me.” You know the old Persian poem translated into English : “I came to see my beloved. The doors were closed. I knocked and a voice came from inside : ‘Who art thou ?’ ‘I am so-and-so.’ The door was not opened. A second time I came and knocked ; I was asked the same question, and gave the same answer. The door opened not. I came a third time, and the same question came. I answered ‘I am thee, my love,’ and the door opened.” Worship of the Impersonal God is through truth. And what is truth ? That I am He. When I say that I am not thou, it is untrue. When I say I am separate from you it is a lie, a terrible lie. I am one with this universe, born one. It is self-evident to my senses that I am one with the universe. I am one with the air that surrounds me, one with heat, one with light, eternally one with the whole universal Being, who is called this universe, who is mistaken for the universe, for it is He and nothing else, the eternal subject in the heart who says, “I am,” in every heart—the deathless one, the sleepless one, ever awake, the immortal, whose glory never dies whose powers never fail. I am one with that.

In the dynamics of life certain universal truths or values come to the fore. The Impersonal God concept embraces them all. That is because it is synonymous with nature or universe. In fact the Impersonal God is born out of the interaction of the human intellect with nature. If man hadn’t existed, nature would still be there, but the Impersonal God wouldn’t have

arisen. God, whatever be the definition, is a subjective force, it is a human creation/invention.

Consider the giant leap of Hanuman across the vast ocean to alight early at Ravana's Lanka where Sita is kept in captivity. For Hanuman it is *Rāma kārya* (duty ordained by his master Rama). Mid-ocean there juts out from the deep waters Mainaka, the hill, who beseeches the great ape to rest on him awhile and then continue the flight. Hanuman politely declines Mainaka's *ātithya* (hospitality) saying "*Rāma kārya* cannot wait." At that moment of apparent conflict between *swahita* (self-interest) and *kar-tavya* (duty) it is the imperceptible Impersonal God who puts Hanuman on the only rightful course : duty first always and every time.

Burning with uncontrollable rage a person jumps on his son to slay him. yet at that critical moment sobriety flashes within him like a warm sun on a rainy evening "thou shalt not kill ; and whosoever shall kill shall be in danger of judgment . . . ye are the salt of the earth : but if the salt have lost his savour, where with shall it be salted ?" (*Matthew*)

The above are but two simple illustrations where the Impersonal God springs out from within and sets the moral tone for the person. Conscience is its other name. For Gandhiji it was his Inner voice.

With apologies to Keats, one may assert

Duty is God, God duty—that is all

Ye know on earth, and all ye need know

Your life is a success, average or a failure according as (for you)

Duty \geq Self
 $<$

7. Religion

Religion, like authority, is also a man-generated force. This word encompasses within its fold God, morality, values, religious feelings etc. Now, religion derives its strength from the deeds and preachings of Great Men, the written word enshrined in the Scriptures, mythology and epics, and the interpretations or discourses given by religious leaders from time to time.

Notwithstanding all these factors, religion too is a subjective force. Nature, the ultimate arbiter, does not recognize religion : thus the myriads of religions that continue to *possess* mankind or with which mankind is *obsessed* for generations past—Hinduism, Buddhism, Judaism, Christianity, Islam, Shinto and others—are simply not legal tender in nature. The species *Homo Sapiens* alone is recognized by nature: the elephant does not belong to any religious faith nor the lion has any caste denomination !

The origin of religion is in the cosmic religious feeling emanating from the human psyche : the feeling of thrill, wonder, admiration, curiosity, and a certain trace of fear too that effervesces within one when one is sublimated by the grandeur of the night sky, awestruck by the deep vast ocean in turmoil or decimated by the ominous silence of the Himalayan giant.

Over the aeons religion has evolved into a discipline, indeed a well-knit institution of life. One can recognize a broad pattern in its structure :

1. *God* (personal/impersonal) : Fountainhead of religion, religiousness and religiosity. This is the Gangotri from which the rivers of religion emanate.

2. *Scriptures* (inspired words) : Collections of hymns, verses, psalms etc., all glorifying the

Creator's bounteousness and mercifulness. These are accepted as God's words (*dicta*) communicated to the human beings for their welfare and emancipation through Saints, Sages, Seers, Prophets, Avatars, Devadutas and such other mystics. Total allegiance to and unquestioned belief in Scriptures are the very warp and woof of the religious fabric. Faith in God means faith in Scriptures, total submission to the priestly class—such is the powerful grip of religion. Now, if such a faith is not based on one's own capacity and nature's impartiality, it will make the person a slave to others. Of all the slaveries the intellectual slavery is the worst. Religious faith should not lead to intellectual slavery, it should promote self-confidence, self-respect, and mutual love.

3. *Temples* (holy centres) : Places of worship with or without an idol of the God. People congregate here to offer prayers, participate in religious rites and rituals, listen to discourses or settle their personal problems. Temples may be centres of learning too with emphasis on religion, philosophy and connected disciplines.

4. *Rituals* (religion-inculcating drill) : The do's and don'ts as prescribed by the clergy, purohits, Devamanavas and such other blessed "agents of God." They are the trusted custodians and authentic interpreters of the Scriptures.

5. *Rewards and punishments* : These are the ways and means of protecting the religious persons (assumed to be righteous always) and punishing the irreligious ones (assumed to be wrong always). In the ultimate analysis the religious and the pious attain heaven (*swarga*) while the irreligious and the impious sink to hell (*naraka*).

6. *Clergymen or purohits* : The authentic expo-

nents of the Scriptures. Religion speaks through them. In all disputes their decision shall be final.

Thus what religion is to the psyche so is authority to the physique. Both are human inventions necessitated by the circumstances and environments where life developed. "God is the finest invention of the human mind" remarked Subrahmanyan Chandrasekhar (1910-95) whose scientific research to "see" God in the celestial objects led to the discovery of *Chandrasekhar limit*.

Here is a story told by Pa. Vem. Acharya :

Alex, an old farmer, lived alone on his land. Busy working with nature he was healthy, helpful and happy. He never prayed, nor visited the Church right in front of his farm.

Rev Fr Serbi, the lone priest in the Church, was a very pious servant of God and His creation. To this believer, the nonbeliever Alex was an enigma : how can a good man be irreligious ?

Every morning Serbi would walk into Alex's farm : "Welcome Father Serbi ! How is your nonstarter God ? Have a cup of coffee which you like so much. Your prayers to God just can't get you this beverage ! Only work with nature can."

Serbi's sincere attempts at "educating" Alex never succeeded. The morning coffee-breaks continued, Serbi honestly looking forward to the day of deliverance for the 'pagan' Alex.

That was not to be. On that fateful morning Serbi found that Alex had died the previous night. "May his soul rest in peace !" prayed the priest, notwithstanding the lurking doubt—did he not die a nonbeliever ?

Years later. Serbi also had to answer the final call.

At the gate of the Heaven. God's messengers received the great soul to usher him into the Almighty's presence.

"But wait, I want to see Alex."

God, being *bhaktābheeshtadāyaka*, had to concede Serbi's wish.

Serbi with the messengers crawled through dark labyrinthine gullies. Unbearable stench and woeful cries. Yet they crept to the limit of their tolerance.

And lo ! A shimmer of light cutting across the abysmal

darkness, a whiff of fresh air breathing life into the petrified agony and above all the inviting invigorative fragrance of coffee, suddenly unfolded before Serbi, a verdant expanse radiating joy.

And there under a richly green tree was Alex working with nature. "Welcome Father Serbi, the ardent devotee of the non-existent and nonstarter God ! Do sip your cup of joy, the delicious coffee, which is nature's gift and not God's boon !"

To the baffled and spellbound Serbi, the realist and pragmatic Alex spoke just nine significant words : "Honest purposeful work makes a heaven of a hell !"

Moral ? : God ? Yes. If you believe, but not at the expense of duty. If you think and act in the manner that God and duty are different, your life will be full of contradictions.

King or the government symbolizes authority while priest or temple religion. Under ideal conditions, as in utopia or *Rāma Rājya*, the king and the priest should work in unison with the sole aim of achieving the well-being of all—*sarvejanāssukhino-bhavantu*.

Such a symbiotic existence is a rare exception, and even here its spell is but short-lived. This is because when the institutionalized authority or religion tastes the wine of power it develops a greater thirst for it. Power intoxicates, and absolute power absolutely. Therefore, the general situation is that one is after the throat of the other to gain absolute supremacy over the people/nation. In fact history tells us religious wars (including the communal riots) are deadlier and have claimed more lives than the conventional ones, nuclear holocaust included.

One is tempted to say : authority is the antithesis of religion, and vice versa ; a synthesis of the two alone can achieve peace and harmony in the society. yet they come together, not out of any self-realization of their goals, but out of concealed selfish interests. For authority it is the expansion of the power base,

while for religion it is the prospect of proselytization. When once the limited success or “conquest” is achieved they fall apart. You cannot wage a proxy war, hide a Trojan horse or cover a Shurpanakhi face for long.

8. Science

So far we have seen in detail two of the three man-generated forces : authority, religion. For authority it is the Constitution and for religion the Scriptures that act as fallbacks and arbiters. What is said or written in them as interpreted by their present day official spokesmen becomes the law. Any thing out of tune with them is blasphemy and is punishable. But life is infinitely richer and more creative than its own creations !

Rev Fr Anthony de Mello, SJ, in his book *Song of the Bird* writes under *Amend the Scriptures* :

Some one said to the Buddha, “the things you teach, sir, are not to be found in the Scriptures.”

“Then put them there,” said the Buddha.

After an embarrassed pause the man went on to say, “may I dare to suggest, sir, that some of the things you teach actually contradict the Scriptures ?”

“Then Scriptures need amending,” said the Buddha.

A proposal was made at the United Nations that the Scriptures of every religion be revised; everything in them that leads to intolerance or cruelty should be deleted ; everything that damages the dignity of human beings should be destroyed.

When it was learnt that the author of the proposal was Jesus Christ, reporters rushed to his residence. His explanation was simple : “Scripture, like the Sabbath, is for the human beings not human beings for Scripture.”

Jawaharlal Nehru (1889-1964) writes in *Glimpses of World History* (the last letter) :

To understand a person who lived long ago, you will have to

understand his environment, the conditions under which he lived, the ideas that filled his mind. It is absurd for us to judge of past people as if they lived now and thought as we do. There is no one to defend slavery today, and yet the great Plato held that slavery was essential. Within recent times scores of thousands of lives were given in an effort to retain slavery in the United States. *We cannot judge the past from the standards of the present.* Every one will willingly admit this. But every one will not admit the equally absurd habit of *judging the present by the standards of the past.* The various religions have especially helped in petrifying old beliefs and faiths and customs, which may have had some use in the age and country of their birth, but which are singularly unsuitable in our present age (emphasis added).

What do these two extracts indicate ?

1. Life is larger than authority and religion, which are but its creations.

2. One should tune one's antenna to the present and aspire for a better future. Procrastination is the enemy of creativity.

3. In the case of a conflict arising between reality (read 'present') and theory (read 'past') reality alone should have the final say (last laugh) always and every time. Theory should reflect reality, and not the converse.

4. Head (read 'reason') and heart (read 'compassion') should act as complementary essentials of a good life : reason tempered by compassion and compassion reined by reason.

Such rational thoughts, and action in accordance with them, should pervade every walk of life. Yet the individual's ego, self-interest, myopic outlook, fear of facing reality in all its ugly nakedness etc may prevent him from following it. He may be 'possessed' by several superstitions too. For example rationalization of the irrational. This is a sophisticated veneer.

over our pet irrational acts. It happens in the deepest recesses of our subconscious mind. Consequently we often lose our reasoning power, fall helpless preys to the octopus embrace of superstition, and in the extreme case may even start openly justifying it too !

Now, in science no such fooling others or self-deception is possible. Because science in its entirety is the perception and interpretation of nature, discovery and enunciation of its laws, and verification and confirmation of the findings with reference to nature itself.

Here then are the three man-generated forces which affect us individually and societally from birth to death :

1. *Authority* : Emanates and accumulates in the interaction between human beings. King or the Constitution is the source that sustains it.

2. *Religion* : Resurges and flows out of the speculation of the human intellect on the unknown assumed to be knowable. Scriptures or religious leaders are the ultimate sources that provide religion strength and authenticity.

3. *Science* : Results from the human intellect working logically and experimentally with the physical universe—that is, nature. Here nature itself is the sounding board and supporting base.

The first two are subjective forces, not tenable in nature. The third force is an objective one, relevant in nature. It means : authority and religion change from people to people, place to place and time to time, while science grows and develops with time. Scientific results are universal. There is nothing human about science like Indian science, Pakistani science, American science etc. Limited experiments at evolving world government and universal religion have

soon degenerated into *my* Government and *my* religion and eventually to *me* ! Here are to be found the seeds of fascism, the poison of fundamentalism and the virus of fanaticism deep down the abyss of human psyche. By their very nature authority and religion do not admit of universalization. True, small is beautiful and stable while big is ugly and unstable.

The very personality of science is universality. You have one physical universe existing in spacetime, and one human race—an infinitesimally small part of this universe—trying to understand the eternal riddle. What little understanding man gains from time to time is the common property and heritage of mankind.

Life is like a tripod resting on the three legs called *authority, religion* and *science*. For the equilibrium of the tripod it is essential that the legs are healthy, uniform, of the same height and one sustaining and complementing the other two. If not, or when this is not the case, the apple cart will topple. The state of mind of a person who is an integral part of such a healthy and vibrant society is termed *Scientific Temper*. Why *scientific* ?

9. Foundations of Science

An assumption is a statement accepted as universally true. Any scientific theory or mansion rests on several assumptions. The experience man gained during his eternal quest for beauty that pervades the universe has resulted in several assumptions. The minimum the number of assumptions the stabler the theory. Assumption is the starting point for the scientific pursuit. It can neither be proved nor disproved. Everyone understands it as such. It is like the taproot

of a tree—supporting, sustaining and nurturing the theory to grow to its fullest potential. If at any time an assumption is proved wrong the theory collapses and is relegated to the catacombs of history. Assumption to a theory is what brick to a building is : in either case it is the human ingenuity that uncovers the mansion shrouded in mystery.

During the pre-Christian and early Christian eras one such assumption that struck the inquisitive and explorative human mind was : earth is the fixed centre of the universe ; all celestial bodies revolve around it.

The scientific theory built on this “universally true” assumption, the geocentric universe or the Ptolemaic System, developed cracks, dangerous fissures too, as it grew to its limits of tolerance.

A theory, even a very sound one at that, is true, within the periphery of its defined frame only, just as a cart is relevant on a hard ground while a catamaran on a sheet of water. The inherent weaknesses or contradictions manifest themselves when the theory reaches its limits of tolerance. The scientist is confronted here with a hitherto-unknown challenge which requires a fresh approach and a new theory. In short, the theory should be able to explain analytically any newly observed phenomenon ; further it should indicate possible greener pastures for investigation ; and explain and assimilate the new findings that pour in. Where it finds itself incapable of rising to the occasion, especially explanation and assimilation of new factors, it begins to creak, develops strain syndrome and finally collapses.

By the 15-16th centuries it was evident that the Ptolemaic System could not fill the bill. And also it was found wanting in explaining the newly accumu-

lated facts. Fresh challenges that arose had no explanation in it. Local repairs and temporary patches would not give enough mileage to its rickety existence. The need for a new look was indeed acute.

Nicolaus Copernicus (1473-1543), a Christian monk by training and profession but a mathematical astronomer by conviction and pursuit, rose to the occasion—*sambhavāmi yuge yuge* is a universally true aphorism. “At moments of acute distress *I* incarnate myself.” He rejected the geocentric hypothesis (in vogue for several centuries BC ; Ptolemy of the 2nd century AD had just standardized it) and established the heliocentric hypothesis, also known as the Copernican System. Earth was “removed” from its “undeserved” position as the centre of the universe and Sun was restored to its “rightful place.”

The main point is that the Ptolemaic System was built on the false assumption that our abode the earth (i. e. *we*) is (are) at the centre of the universe. Do not the scriptures (voice of God) proclaim this ? *In the beginning God created the heaven and the earth . . . God created man in his own image.* You see here how religion and science are intertwined in a rather complex manner and the fact imprinted in the human psyche for generations. Yet reality, and its interpretation science, do assert their real nature with the advancement of time and research. You cannot hide truth for long.

Real science as we understand it today took its birth in the Copernican or heliocentric revolution—it was not just a revolution in astronomy (rightly called the mother of sciences) but in the very human psyche itself : the anthropocentric universe receding to oblivion and man’s (in-)significance becoming clearer in the new set up.

Einstein wrote the following message on the 410th anniversary of the death of Copernicus :

We are honouring today, with joy and gratitude, the memory of a man, who more than almost anyone else, contributed to the liberation of the mind from the chains of clerical and scientific dominance in the Occident. . . Once it was recognized that the earth was not the center of the world, but only one of the smaller planets, the illusion of the central significance of man himself became untenable. Hence Copernicus through his work and the greatness of his personality taught man to be modest.

Science is built on a minimum of three independent assumptions :

1. *There is order in the universe.*

This assumption is tantamount to asserting that there is a cause-effect relationship in all natural phenomena. When you perceive an *effect* you know there is a *cause* at its root. This perception motivates you to investigate the cause. In the process science develops. There is no cause without an effect, nor effect without a cause. If for any new phenomenon you are unable to discern the cause, despite your best efforts in the highest traditions of science, it is an indication that there 'lurks' a new 'mystery' of nature. Maybe the time and climate (and even the person concerned because of his limitations) are not ripe for fitting the phenomenon to the cause-effect frame.

Towards the end of the 19th century a new phenomenon (*effect*) struck a discordant note in the otherwise even refrain of physics. Spontaneous emission of energy (*effect*) without any perceivable provocation (*cause*). Something like an automatic generation of energy which would defy all known laws of physics, and so shake the very vertebral column of science. Determined pursuit and dogged tenacity with complete faith in the efficacy of science led to the dis-

covery of radioactivity (1896). The hidden 'culprit' or *cause* was thus ferreted out.

In each of such critical confrontations with nature—effect without cause or cause without effect—the scientist knows he and his theory are facing a new realm of fresh nuggets. Hence a scientist who is thus wedded to his pursuit may echo with poet Rabindranath Tagore : “Thy infinite gifts come to me only on these very small hands of mine. Ages pass, and still thou pourest, and still there is room to fill.”

2. *Man has the capacity to perceive, understand, explain and communicate the order prevalent in the universe.*

The entire history of science bears ample evidence to this assumption. In fact this is a universal law embracing in its fold all human activities. Tradition flows through communication while communication rests on the very texture of the human psyche. In fact communication is the oxygen of life. Isaac Newton (1642-1727) has beautifully expressed this thought in a metaphor : “If I have seen further than other men, it is because I stood on the shoulders of giants.” That is why we of today are the inheritors of the accumulated knowledge of the past.

3. *“God is subtle, but malicious he is not.”*

This is a quotation from Einstein. Here *God* symbolizes nature or the universe. The structure and mechanism of nature are indeed very *subtle* at every level from the microcosm of the atom to the macrocosm of the star. They are certainly complex, but not beyond human comprehension. When a person is deeply engaged in the understanding and codification of the laws of nature he realizes that it does not play hide-and-seek game with him.

On different occasions Einstein had remarked :

“God does not play dice,” “It is hard to sneak a look at God’s cards. But that he would choose to play dice with the world . . . is something I cannot believe for a single moment,” “ I can, if the worse comes to the worst, still realize that God may have created a world in which there are no natural laws. In short, chaos. But that there should be statistical laws with definite solutions, i. e., laws that compel God to throw dice in each individual case, I find highly disagreeable.”

These aphorisms divested of their metaphorical externalities simply mean : nature has no “intention” to help you with your investigation work, nor “aversion” against you ; it has no mind, no heart, it is just like that where it is, and it functions according to its own laws. You can extract out of the not-unfathomable caves of ocean its “secrets” provided you follow the rules of the game as prescribed by it, and not as fancied by you. Philosopher Karen Blixen writes : “The rich and the poor are two locked caskets, of which each contains the key to the other.” Substitute *nature* for *the rich* and man for *the poor*, and lo ! You’ve unlocked the caskets, or opened the cave of Ali Baba.

Richard P. Feynman (1918-88) says :

The law of Gravitation has been called ‘the greatest generalization achieved by the human mind’ . . . I am interested not so much in the human mind as in the marvel of a nature which can obey such an elegant and simple law of gravitation. Therefore our main concentration will not be on how clever we are to have found it all out but on how clever nature is to pay attention to it.

He has corroborated the point *how clever nature is* on a different context:

If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most

information in the fewest words ? I believe it is the *atomic hypothesis . . . that all things are made of atoms—little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another* (emphasis added).

Let us now imagine a situation in which the three basic assumptions are negated. The negation of the first assumption would require an orderless universe. In such a chaotic condition no life would evolve. If the second one is negated the humans would be degraded to the state of animals and plants. The negation of the third assumption would require a dice-playing God with His own creation, i.e., nature should be endowed with a mind ! Thus it gets de-natured and devalued.

Suppose the assumptions were absent ? In the absence of the first one the second would become redundant. If the second assumption were absent, science would not have sprouted. And, the absence of the third one would deprive the scientist of an independent and objective criterion for testing the veracity or otherwise of his findings. Consequently science would lose its very integrity and cohesion.

Thus these assumptions are both necessary and sufficient for building the scientific edifice. The first assumption sets the *purpose*, the second motivates the *pursuit*, while the third assures *pleasure* in playing the game (fun) called science.

10. Pursuit of Science

Why pursuit of science ? A prosaic answer is : because it is there, invisible yet perceptible, and challenging man to the limits of his competence and perseverance ; because he derives joy in this (fun) ;

because the application of science, called technology, makes man's life more comfortable ; and because human psyche is tuned to nature's music.

S. Chandrasekhar puts it metaphorically thus :

The pursuit of science has often been compared to the scaling of mountains, high and not so high. But who amongst us can hope, even in imagination, to scale the Everest and reach its summit when the sky is blue and the air is still, and in the stillness of the air survey the entire Himalayan range in the dazzling white of the snow stretching to infinity ? None of us can hope for a comparable vision of nature and the universe around us. But there is nothing mean or lowly in standing in the valley below and awaiting the sun to rise over Kanchanjunga.

Pursuit of science is a one-sided game that man, an infinitesimally small and insignificant, but integral part of nature, is playing with his creator the nature. The rules are absolutely clear, cold and cuttingly objective—always nature-oriented and never man-made or man-friendly.

“In the beginning” there was no science but only the human mind or intellect pitted against nature. Intellect is “the ability to reason, perceive or understand ; ability to perceive relations, differences, etc.” A dominant hue of the intellect is curiosity which is “a desire to gratify the senses with a sight of what is new or universal, to gratify the mind with new discoveries ; a desire to learn about things that do not necessarily concern one; inquisitiveness” (*Webster*).

Thus symbolically speaking, the stimulus offered by ‘nature’ illumines the ‘intellect’ and generates the response ‘curiosity.’ Rudyard Kipling (1865-1936) has written a doggerel :

I keep six honest serving men
(They taught me all I know) :
Their names are *what why* and *when*
And *how* and *where* and *who*

We can add a *which* to this list. Now, curiosity activates the “six honest serving men” plus one to find out the *cause* behind the *effect* produced by the particular natural event (stimulus).

Abhaya, Akshari and Anarghya, three young children, bubbling with curiosity and bursting with queries, shoot the following seven questions at me :

What is the future of our sun ?

Why do birds chirp in the morning ?

When will the next total solar eclipse appear at our place ?

How do plants get water and minerals ?

Where did life emanate first—earth, other planets, comets etc ?

Who discovered the genetic code ?

Which is the largest prime number ?

To get a satisfactory answer to any of these questions one should pursue a systematic approach, should separate the essentials from the irrelevant, and think intuitively as well as logically. Even then there is no guarantee that one will arrive at the right answer. But such a pilgrimage of eternal inquiry—the adventure of ideas—makes one better fitted to seek a solution. Further while traversing such an unknown terrain one will be rewarded with unexpected bonuses, serendipitously, if you prefer. New questions and queries will arise suggesting other avenues of investigation. Whether one succeeds or not in getting the answer eventually is irrelevant. What is most relevant is one's objective and approach. The real joy is in walking, and not in reaching (journey versus destination).

Isaac Asimov (1920-92) describes rightly Thomas Alva Edison (1847-1931) as the second Archimedes (BCc 287-212). Such was the inventive genius of Edi-

son. Asimov writes :

Edison had no patience with slow and analytical thought. His favourite method of working was to read everything and try everything in an all-devouring attack on every phase of a problem. He often conquered by sheer weight of effort. When eight thousand attempts to devise a storage battery failed, he said, "Well at least we know eight thousand things that don't work." "Genius" he said scorning those who spoke of insight, "is one per cent inspiration and ninety-nine per cent perspiration." This worked for him, to be sure, but there are few human beings with Edison's capacity for perspiration.

The Greek astronomer Eratosthenes (BCc 276-c 196), a contemporary of Archimedes, gave what was later called the 'Sieve of Eratosthenes.' How to separate or sieve out the prime numbers from the 'mixture' of positive integers 1, 2, 3, 4, 5. . . ? Positive integers (except 1) which are not divisible by any other positive integer except 1 and themselves are called prime numbers. The number 1, the universal factor, is excluded from the list. Thus the first few prime numbers are 2, 3, 5, 7, 11, 13, 17, 19, etc. Eratosthenes gave a delightfully simple procedure to handpick the primes : beginning with 2 and with reference to every number, strike out its multiples. Consider the series of positive integers from 2 to 100. The scene after applying the Eratosthenes' technique would look :

| | | | | | | | | | | | | |
|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|----|
| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | |
| 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | |
| 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | |
| 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | |
| 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | |
| 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | |
| 99 | 100 | | | | | | | | | | | |

The 'fortunate' survivors are the prime numbers less than 100. They are

2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43,
47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97

The Eratosthenes sieve technique is universal. You can raise the upper limit to any big number, say, 10^{100} (called a googol) or 10^{googol} (called a googolplex) or still bigger numbers. (Incidentally try to write the number googolplex fully.) However, the mechanicalness of the method will soon get over your nerves. Some of the lanes and bylanes that appear during this "mass massacre" of non-prime numbers are :

What is the formula for generating prime numbers only ?

Why do prime numbers appear at irregular intervals ?

When do you say whether a given number is prime or not ?

How many prime numbers are there less than a given number n ? Is there a formula to determine it?

Where do you fix the prime number 11111....1 (1 repeating 317 times) in the prime number series 2, 3, 5, 7, 11 . . . ? Or what is its position number?

Which of the two series—the series of positive integers and the series of prime numbers—has more number of terms ? (i.e., 1, 2, 3, 4, 5, . . . ; 2, 3, 5, 7, 11,...)

The answers to these apparently simple questions will take us to the theory of numbers.

Thus science by its very structure compels us to chalk out a programme for the investigation of any problem. This programme is called the *scientific method*.

11. Scientific Method

For tackling problems in the field of science this method is both compulsive and essential. Consider the simple phenomenon nature unravels before us: the sun, moon, planets and the stars are equidistant from us, and are continuously revolving around us in the east-west direction. Our ancients thought that there is a solid sphere out there holding all the celestial bodies to its inner surface and we are at its centre. This is the *real solid* blue celestial dome of the ancients' comprehension. The sphere rotates in the east-west direction, and the fixed objects revolve likewise. However this *visible fact* is a myth ! Yet in the pre-Christian times when man was beginning to employ his seven honest serving men to ascertain the *cause* behind the apparent *effect* this was the slowly emerging *hypothesis*.

A hypothesis in science is only a first step towards the solution of a problem. More often than not it becomes obvious later that it is a wrong step. One has to resign oneself coolly to such a setback with an Edisonian stoicism : "Well at least we know this hypothesis does not work !" The disappointment can be more and more severe when the scientist faces repeated failures—which however, is the general rule in science. But then nature "does not play dice" with the scientist.

This merciless coldness of nature has made Einstein exclaim :

The scientific theorist is not to be envied. For Nature, or more precisely experiment, is an inexorable and not very friendly judge of his work. It never says 'yes' to a theory. In the most favorable cases it says 'maybe,' and in the great majority of cases simply 'no.' If an experiment agrees with a theory it means for

the latter 'maybe,' and if it does not agree it means 'no.' Probably every theory will some day experience its 'no'—most theories soon after conception.

There are five distinctly discernible steps in the scientific method : definition of the problem, collection and collation of data, formulation of a hypothesis, verification and confirmation of the hypothesis, and enunciation of the theory. The theory is the solution to the problem under definition. A brief explanation of the steps is given below.

1. *Define the problem clearly and correctly.*

The ancients put the question "Why do the celestial objects revolve around us in the east-west direction?" The emphasis was on accepting an apparent phenomenon—the rotation of the celestial sphere as it appears to us—as a physical fact of nature. The individual movements of the objects (in today's parlance, for instance, the evening star becoming the morning star, and vice versa) were separately considered and explained without thinking of any possible interconnections. When two or more such explanations would not coalesce into a coherent logical unit, or would present a contradictory situation, amendments to the original explanation were grafted to tide over the immediate chasm. Patchwork and ad hoc solution were accepted as a way of science.

If, on the other hand, they had asked themselves—"What *forces* of nature *cause* the celestial bodies to move the way they do?"—the course of science would have ushered in the Galilean era much earlier. But every scientist, including a creative genius, is a multi-dimensional complex product of his times. Tradition in science plays an important role in shaping and influencing his thoughts : he can choose, invent or

even foresee what the solid platform of tradition at his time allows him to do. You cannot jump much higher than your own height physically as well as metaphorically. Aristotle (BC 4th century) could not have foreseen or foretold Galileo (AD 16th century), though qualitatively their geniuses might be comparable. To repeat Seneca "Our universe is a sorry little affair unless it has in it something for every age to investigate."

Taking Aristotle and Galileo as metaphors, we note the qualitative differences.

Aristotle : Natural phenomena were explained (and explained away too) by intuition and imagination. Common events, as they occurred, were assumed to be universally true, and generalized as such. The fact of cause-effect inseparability never took deep roots. The weight of the Guru rather than an objective experimental verification with nature was preferred. Thus in the beginning science, in principle, was also a subjective discipline like religion or authority.

Galileo : Forces causing the natural phenomena were looked for. Experiments were devised to imitate nature and get insights into its working. Phenomenon or *effect* is seen, the force or *cause* behind it is to be investigated. This was the Galilean basic refrain, and so of modern science too. It is not the weight of the Guru, however great he may be, but the logic of nature that is of primary concern here. In fact real (or modern) science starts with Galileo, with the establishment of the *cause-effect* relationship. It is an interplay of forces verifiable experimentally. Such a study which includes observation, experimentation and intuitional reasoning is *ipso facto* objective.

The celebrated work *Dialogues concerning Two New Sciences* by Galileo Galelei begins as an allegory:

The constant activity which you Venetians display in your famous arsenal suggests to the studious mind a large field of investigation, especially that part of the work which involves mechanics ; for in this department all types of instruments and machines are constantly being constructed by many artisans, among whom there must be some who partly by inherited experience and partly by their own observations, have become highly expert and clever in explanation.

Thus we perceive a paradigmatic shift in approaches between Aristotle and Galileo : from subjective explanation to objective interpretation of nature, from the observed phenomenon to the underlying cause, and from kinematics to dynamics. (Kinematics is the branch of mechanics which treats of motion in the abstract without reference to the force or mass ; dynamics is the branch of physics which treats of the action of force on bodies in motion or at rest ; and mechanics is the branch of physics that deals with the motion and the phenomena of action of forces on bodies (*Webster*).

Lloyd Motz writes in his introduction to *The World of Physics* :

Although the fruits of their investigations were rather meager, the Greeks exhibited a quality of mind that is comparable to the best of modern era. Why then did they accomplish so little? The reason is that they asked themselves the wrong questions and sought answers in the wrong way. Theirs was not a systematic study of the nature of things in which experiment and theory went hand in hand but a series of unrelated speculations that stemmed from no basic principles and were never tested.... The best example of this is Greek astronomy which was devoted only to the study of the motions of celestial bodies and not to the causes of these motions.

2. *Collect the data and collate them systematically.*

It is understood that the data thus collected have relevance to the problem under consideration. As an

example let us continue with the question put at the beginning of step 1 : “Why do the celestial objects revolve around us in the east-west direction ?”

The obvious answer that struck the primitive astronomers of the pre-Christian era was : the earth has no motion and is fixed at the centre of the universe ; the celestial objects are ordained to revolve around the earth ; this is God’s handiwork ; man’s duty is only to see, enjoy and worship it—never to question the Almighty’s intention. Thus by divine dispensation the geocentric system was accepted as the unquestionable fact of nature—indeed a *fait accompli*.

The next step was to plot the seven clearly discernible moving bodies—Saturn, Jupiter, Mars, Sun, Venus, Mercury and Moon—against the fixed backdrop of the star-constellations. No single individual or group could have possibly undertaken and completed this time-consuming and patience-demanding task. However the intellectuals of those times were neither bitten by the competition bug nor bothered by the communication blitzkrieg.

For them the celestial bodies, by their motions and positions, were communicating to man the Creator’s message in coded language. It is imperative on man’s part to understand the message and follow the dicta implicitly.

Generations of primitive astronomers had observed the sky for the past several centuries of civilization and kept appropriate records. To get a feel of what it means consider the following jumble of 33 numbers :

55, 1, 64, 8, 256, 10, 12, 5, 1, 8, 2, 32, 34, 1,
128, 21, 7, 4, 6, 2, 8, 89, 9, 11, 3, 3, 144, 1, 21,
5, 16, 4, 13 ... (a)

You will naturally want to discipline these numbers and bring order to the apparent chaos. The right thing is to put them in the ascending order :

1, 1, 1, 1, 2, 2, 2, 3, 3, 4, 4, 5, 5, 6, 7, 8, 8, 8, 9,
10, 11, 12, 13, 16, 21, 32, 34, 55, 64, 89, 128,
144, 256 ... (b)

A careful observation of these collected data suggests that you should separate the first 13 consecutive numbers :

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 ... (c)

Removing (c) from (b) you get

1, 1, 1, 2, 2, 3, 4, 5, 8, 8, 16, 21, 32, 34, 55, 64,
89, 128, 144, 256 ... (d)

The proximity of 128 to 256 in (d) triggers your imagination to work backward and handpick the numbers :

1, 2, 4, 8, 16, 32, 64, 128, 256 ... (e)

The numbers that now remain in (d) are

1, 1, 2, 3, 5, 8, 21, 34, 55, 89, 144 ... (f)

Here you notice that the sum of any two consecutive numbers generates the third number—perhaps not ?

$1 + 1 = 2$, $1 + 2 = 3$, $2 + 3 = 5$, $3 + 5 = 8$, $5 + 8 = 13$,
 $8 + 13 = 21$, $13 + 21 = 34$, $21 + 34 = 55$, $34 + 55 = 89$,
 $55 + 89 = 144$... (g)

How to account for the missing 13 ? Very easy : take it out of (c) and restore it to its proper place in (g). Thus the jumble (a) (the *collected* data) now results into the *collated* data :

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 ... (c')

1, 2, 4, 8, 16, 32, 64, 128, 256 ... (e)

1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144 ... (f')

Note the difference between the collected data (a) and the collated data (c'), (e) and (f').

Precisely some such analytical thinking went into the motion of the seven celestial objects : they are ever mobile on the stellar curtain which means they generate numbers. Could there be any recognizable pattern in them ? For instance they can lie along a beautiful geometrical arc, form a circle or any other geometrical figure. The continuous shift in the position of the moon and the associated change in its phase must have attracted their attention first. The earlier observers realized that the moon's orbit is confined to a narrow belt in the celestial sphere. Naturally this belt served as the frame of reference for discerning the locations and movements of the remaining six bodies. Strange ! All of them are 'chained' to move along this belt only. It is the zodiac.

Over the millennia the data collected and collated pertaining to the movements of the seven bodies inspired man to conclude :

(a) the period of revolution of each body around the earth is a constant ; the sun's period came to be known as the year ;

(b) a year has approximately 365 days (the interval between two consecutive sunrises is a day = daytime + nighttime) ;

(c) the moon completes about 12 lunations in a year (the interval between two consecutive new moons is a lunation, approximately 29.5 days) ;

(d) the cycle of seasons repeats after a year ; and

(e) the stellar dome completes a rotation in a year—this rotation is qualitatively different from the diurnal rotation though the directions are the same (east-west).

3. *Formulate a hypothesis and state it.*

Hypothesis is “a supposition ; a proposition or principle which is supposed or taken for granted in order to draw a conclusion or inference for proof of the point in question ; something not proved but assumed for the purpose of argument” (*Webster*).

The second step, i.e., collection and collation of data, presents before you a microscopically small chunk of the whole which is supposed to be the *cause* behind the observed *effect*. Now, out of these scanty but well-ordered data, you have to guess intelligently the *cause*. It appears as though the data inspire you to offer the hypothesis : “I am contained in this grotesque rock. Sculpt me out of it.”

Poet of the Wood V. M. Sholapurkar says “Every wooden log is a frozen song of nature covered by extra material. Remove the cover, you see the song !”

For C. V. Raman (1888-1970) life, nature and physics were synonyms. He puts the questions : why the sky and ocean are blue while the forests and plantations are green ? What secret of nature is treasured in the wayside unimpressive stones that reflect myriads of colour when exposed to different monochromatic lights ? He writes (quoted from *C. V. RAMAN, A Pictorial Biography* compiled by S. Ramaseshan and C. Ramachandrs Rao) :

The face of Nature as presented to us is infinitely varied ; but to those who love her, it is ever beautiful and interesting. The blue of the sky, the glories of sunrise and sunset, the ever shifting panorama of clouds, the varied colours of the forest and the field and the star-sprinkled sky at night—these and many other scenes pass before our eyes on the never ending drama of light and colour which Nature presents for our benefit The man of science observes with the eye of understanding but her beauties are not lost on him for that reason. More truly it can be said that understanding refines our vision and heightens our

appreciation of what is striking and beautiful.

We are like the proverbial blind men in search of an elephant. Finally when they get hold of it one shouts "The elephant is a stocky rope," another exclaims "It's a well-built column," and so on. They can never grasp the totality. Yet if one of them, endowed with a sharp intellect, can collate the various data *intuitively*, he may be able to formulate the rough shape of the animal.

Intuition is that quality of the human mind which enables a person to visualize the whole by getting hold of a part. "The immediate knowing or learning of something without the conscious use of reasoning" is intuition. It is a case of instantaneous apprehension of the problem in its entirety : guessing the wood by glancing at the trees.

Mathematician G. H. Hardy (1877-1947) went to see his protege Srinivasa Ramanujan (1887-1920), a mathematical genius, lying critically ill in a hospital bed. Hardy remarked rather casually "The cab in which I drove here bears the registration number 1729. A very insipid number indeed !"

Quick as an electric impulse sparkled Ramanujan's intellect : "No Mr Hardy ! It is a very interesting number : the smallest number that can be expressed as the sum of two cubes in two different ways !"

$$\text{Yes , } 1729 = 1^3 + 12^3 = 9^3 + 10^3$$

Bigger numbers are there :

$$4104 = 2^3 + 16^3 = 9^3 + 15^3$$

$$13832 = 2^3 + 24^3 = 18^3 + 20^3 \text{ etc.}$$

Hardy asked him : "Any similar example for the fourth power ?"

The disease was acute and the pain excruciating. Yet, Ramanujan thought for a while and said : "Yes,

there is. It is a very large number. Just now I cannot recall it.”

That “large number” is

$$635318657 = 59^4 + 158^4 = 133^4 + 134^4$$

This was given by another mathematical genius Leonhard Euler (1707-83).

Chandrasekhar Limit (=1.4 times the mass of the sun) is a universal physical constant. It determines the future evolution of a star. Stars having masses less than this *Limit* end up as White Dwarfs and die due to loss of radiation ; while those with greater masses proceed further, and may even end up as Black Holes after the supernovaic explosion. The concept is extremely simple though the spinoffs are solid and complex.

In my interview with S. Chandrasekhar (1910-95) on 22, 23 June 1995 I asked him : “What was the motivation for you to arrive at this deceptively simple physical constant ?”

With a disarming candour he chuckled : “Well, it was lying there in the various research papers. Anybody could have picked it up. I happened to be the first !”

Then he quoted the following passage from his illuminating essay *The Pursuit of Science : Its Motivations* :

“Perhaps the most moving in this general context is that of Heisenberg relating the moment when the laws of quantum mechanics came to a short focus in his mind:

. . . One evening I reached the point where I was ready to determine the individual terms in the energy table, or, as we put it today, in the energy matrix, by what would now be considered an extremely clumsy series of calculations. When the first terms seemed to accord with the energy principle, I became rather

excited, and I began to make countless arithmetical errors. As a result, it was almost three o'clock in the morning before the final result of my computations lay before me. The energy principle had held for all terms, and I could no longer doubt the mathematical consistency and coherence of the kind of quantum mechanics to which my calculations pointed. At first, I was deeply alarmed. I had the feeling that *through the surface of the atomic phenomena, I was looking at a strangely beautiful interior*, and felt almost giddy at the thought that I now had to probe this wealth of mathematical structure nature had so generously spread out before me. I was far too excited to sleep, and so, as a new day dawned, I made for the southern tip of the island, where I had been longing to climb a rock jutting out into the sea. I now did so without too much trouble, and waited for the sun to rise.

"There is no difficulty for any of us in sharing Heisenberg's exhilaration of that supreme moment." (Emphasis is added.)

It was Heisenberg's intuition that *was looking at a strangely beautiful interior* or peeping at the Lord's cards.

Arthur Koestler (1905) explains the role of intuition thus :

The moment of truth, the sudden emergence of a new insight, is an act of intuition. Such intuitions give the appearance of miraculous flashes, or short circuits of reasoning. In fact they may be likened to an immersed chain, of which only the beginning and the end are visible above the surface of consciousness. The diver vanishes at one end of the chain and comes at the other end, guided by invisible links.

Towards the end of the 19th century, physics was beset with three major crises : the quantization of energy, the medium for the propagation of light, and the structure of the atom. It was given to the intuitive geniuses of Max Planck (1858-1947), Albert Einstein (1879-1955) and Niels Bohr (1885-1962) to resolve them by heralding, what since then has come to be known as, Modern Physics (Quantum theory, and Relativity theories—Special and General). The

theory in vogue till then is called the Newtonian or Classical theory.

Abraham Pais (1918), a biographer of both Einstein and Bohr, writes :

Einstein and Bohr are two of the three physicists without whom the birth of that uniquely twentieth-century mode of thought, quantum physics is unthinkable. The three are in order of appearance : Planck the reluctant revolutionary, discoverer of quantum theory who did not at once understand that his quantum law meant the end of an era now called classical. Einstein, discoverer of the quantum of light, the photon, who at once realized that classical physics had reached its limits, a situation with which he could never make peace. And Bohr, founder of the quantum theory of the structure of matter, also immediately aware that his theory violated sacred classical concepts, but who at once embarked on the search for links between the old and the new, achieved with a considerable measure of success in his correspondence principle.

The role of invisible links or search for the links between the old and the new is played by intuition. Einstein explains this point thus :

All great achievements of science start from intuitive knowledge, namely in axioms, from which deductions are then made . . . Intuition is the necessary condition for the discovery of such axioms.

Let us now continue with the question put at the beginning of step 1 and discussed in step 2 : “Why do the celestial objects revolve around us in the east-west direction ?”

The spell of magic cast by the unreachable celestial heights, housing myriads of light-points and bright discs all dancing to an unknown melody, had captivated the imagination of the primitive man. Seeing, observing, guessing the reasons, recording unusual events, trying to link them etc went on at several centres of civilization. S. N. Sen writes in *A Concise History of Science in India* :

... these suggested methods of marking and measuring time to an intelligent priestly class wherever human civilizations sprang up and had their normal course of development. This priestly class, as is well known, had a dominant role to play in human societies, with powers to regulate religious and, not infrequently, the secular life of their fellow members.

He continues—

As to sciences, their origins, although couched in mythological forms are traceable to the *Rgveda*. Reference to the threefold division of the heaven, the sun and the moon, their motions through stellar constellations, solar eclipse, division of time in days, months, year, intercalation etc., clearly herald the beginning of astronomy and calendrical science.

The date of *Rgveda* (the earliest of the four vedas) is fixed about 1500 BC.

Arthur Berry in *A Short History of Astronomy* writes :

Several peoples who reached a high state of civilization at an early period claim to have made important progress in astronomy. Greek traditions assign considerable astronomical knowledge to Egyptian priests who lived some thousands of years BC. . . Chinese records describe observations supposed to have been made in the 25th century BC; some of the Indian sacred books refer to astronomical knowledge acquired several centuries before this time ; and the first observations of the Chaldean priests of Babylon have been attributed to times not much later. On the other hand, the earliest recorded astronomical observation, the authenticity of which may be accepted without scruple, belongs only to the 8th century BC.

In those days, at the dawn of civilization, whoever and wherever he observed the sky intently for long and tried to propose a hypothesis, could not have improved on the one flashed by Aristotle (BC 384-322). The collected and collated data were there. His brilliant intuition led him to propose the geocentric (earth-centred) hypothesis. For, as already explained, God had cast man after His image and placed this tiny creature on the earth. God had created the earth

earlier. It was therefore in the fitness of things, as the accumulated knowledge and the social fabric required then, that man's place should be supreme and his abode at the centre of the universe. Thus man and his home got a pivotal position. One sees the play of man's ego here, subtly but unintended.

Aristotle's was undoubtedly a giant leap of intuition. By then the approximate "periods" of the seven moving objects had been computed through painstaking observation, data collection and collation. *Period* is the time taken by the object to complete a revolution around the earth with reference to the fixed stars. Mark the position of moon any night on the fixed stellar backdrop. Suppose it is near the red star Betelgeuse (Ārdra), the north-east constituent of the Orion constellation (Mahāvyaḍha). Continue to note its position with reference to this star each successive night. The moon displays a clearly discernible eastward glide. At the end of about 27.3 days it will have arrived at the starting point from the west.

The periods of the 7 objects as computed then and arranged in the descending order are (figures within brackets indicate the refined modern values in the same units, which are but slight improvements on what they had reckoned then) : Saturn 29.5 years (29.46), Jupiter 12 years (11.86), Mars 2 years (1.881), Sun 365.25 days (365.2422), Venus 225 days (224.7), Mercury 88 days (88); Moon 27 days (27.33).

Except for the planet Mars the near coincidences are as amazing feats as they are tributes to the analytical perception of those pioneers in astronomy. The unusually high discrepancy (6.326%) in the case of Mars is due to its apparently erratic movements which they could not explain properly : though the other planets Mercury, Venus, Jupiter and Saturn

also exhibit retrograde motion (east-west movement on the stellar curtain) the observed discrepancy is of a very small order (1% or less). The real point of interest to us here is that they had done it—an astronomically astounding feat.

The occultations, i. e. the passages of the moon over a planet or a fixed star, and the eclipses must have suggested that the objects are not equidistant from the earth. The moon is certainly the nearest as no other body comes between the two. Regarding the remaining six objects, their periods must have led the ancient astronomers to conjecture that the larger the period the farther the object. Such a conclusion was born of local experience of course. This explains why the seven moving objects were arranged in the order stated above.

Still it was descriptive astronomy only. The whys and hows had to wait for a long time to get their answers. It was mainly Claudius Ptolemy's (flourished about AD 140) intuition that gave a geometric frame to the geocentric system. It is the geometry of spheres. Ptolemy visualized a set of eight concentric, transparent and hollow spheres with earth as the fixed centre. These house, in the order of increasing distances from the centre, Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn and the fixed stars. All of them rotate around the centre (earth) in the east-west direction completing one rotation in a day—this is the diurnal motion. To account for the west-east motion of the seven objects Ptolemy invented epicycles for each of them. Since these circles, epicycles and circles within circles are but ingenious inventions of the human mind, and today they are only of historic interest to a student of astronomy, we will not worry about them. Artifices and artefacts have an

improbable way to maintain the geocentric and thus eventually destroy the very purpose of introducing them. That was precisely the eventual fate of the geocentric model.

The geocentric system got its new name, viz., the Ptolemaic system/universe. Its geometry worked. Observed data could be explained by this model while the future events predicted by it did happen accordingly, thus confirming its veracity. Inexplicable, minute though, were explained away either as observational errors or new data to be appropriately fitted into the Ptolemaic model.

4. Test or verify experimentally the hypothesis vis-à-vis the original problem (real nature)

The problem we have chosen is "Why do the celestial objects revolve around us in the east-west direction?" The Ptolemaic hypothesis with its transparent spheres, circles, epicycles etc. had no doubt explained reasonably well the observational data up to a point. That would mean, in Einstein's words quoted earlier, the hypothesis had secured its *maybe*. If however the experiment or observation, even on a subsequent occasion, were to say *no* to the hypothesis/theory it would be relegated to the waste-paper basket of relentless time.

Such a hypothesis which passes the crucial test of experimental verification—that is with reference to reality as the sounding board—is called a theory. Ptolemy's geocentric model attained this status and reigned supreme till the 15th-16th century.

No theory is permanent nor perfect. Every theory will have to face its *no* one day or the other. This is because the universe is too wide, too long and too intertwined in spacetime, and man, an infinitesimally

mally small fragment of it, is endowed with too little power to comprehend it fully. No one is sure whether the ultima Thule is there but every one is sure that man can never attain it. The only course open to him is eternal progress, not always on the right tracks. He can reject the wrong ones and choose others and proceed in the Edisonian manner. The name of this activity is science.

The history of science is replete with instances where theories that seemed invincible at a point of time were discarded at a different point of time as used-and-torn garment out of fashion. Theory then, is the temporary raiment fitted on to the reality as known at that time. As the knowledge about reality develops with the advance of time, it overgrows the attire and the only way open is to find a new set of robes.

5. Declare the experimentally confirmed hypothesis as theory.

Adverting to the original problem "Why do the celestial objects revolve around us in the east-west direction ?" We had Ptolemy's geocentric theory.

Whatever be the form of human activity— authority, religion, science or an admixture of all the three—when once it gets institutionalized it develops its own vested interests and builds a coterie around itself which will insulate the system from any fresh air or new ideas "polluting" it : the holy cow should be protected from the pagan marauder ! The hermetically sealed system generates subjectivity which gradually cuts into the vitals of the system, and erodes its credibility. Science is no exception to this universal rule governing all human-generated activities.

In the post-Ptolemy era the geocentric system,

strongly supported by the astronomers and vehemently upheld by the clerics evolved into a closely knit powerful school. Any doubt or discordant note would be put down with a heavy hand. For, such a melancholy note would amount to questioning the Creator's (read the religio-scientists') very wisdom. It is not for us, the humble mortals, to pick any odd patch in this divine mosaic. Of course, the interpreters of the divine mosaic were the clerics as enshrined in the Scriptures—reality ought to be the reflection of the Scriptures ! (page 22)

Such was the fractured locus of the geocentric system : starting on the wrong foot, evolving along an erratic route, facing contradictions and complexities beyond its comprehension, yet refusing to read His book (the sky), and finally hitting a dead-end. Almost 20 centuries of unabated reign, the geocentric model became an integral part of the human psyche. Yet it had no bottom and was false. No doubt it explained celestial events and helped to predict eclipses accurately. But that would not be an insurance against its falsity. Mathematical calculation is a means to an end, and not the end it self—at best the Ptolemy model was a mathematical arrangement of reality.

12. The New Science

The cup of contradictions in the geocentric model was brimful. The ocean of new data that had accumulated over the centuries could neither be accommodated in it coherently nor explained by it logically. And in Europe the renaissance—"transitional movement . . . between medieval and modern times beginning in the 14th century in Italy, lasting into the 17th century, and marked by a humanistic revival of

classical influence expressed in a flowering of the arts and literature and by the beginnings of modern science" (*Webster*)—had set in.

To mark the 500th birth anniversary of Nicolaus Copernicus (1473-1543), a product of renaissance, who rejected the geocentric model and gave us the heliocentric one, thus paving the way for the new or modern science and the scientific method, the Smithsonian International series brought out in 1973 a reference work entitled *The Nature of Scientific Discovery* edited by Owne Gingerich. In this book Owsei Temkin begins the essay *Science and Society in the Age of Copernicus* thus :

Those of us who can look back over the past seventy years may well claim to have witnessed a period unique in the history of mankind. If we look for another seventy years equally fraught with momentous events, none perhaps can compete with the age of Copernicus, the seventy years from his birth in 1473 to his death in 1543.

The discovery of America, first journey around the earth, industrial revolution, printing press, nation states on the upsurge etc gave a new fillip for the all-round progress of science. There was an imperceptible but definite paradigm shift in the scientific method—from the descriptive of the ancients to the mathematical of the moderns.

Temkin continues,

All this agrees well with the discovery by Andreas Vesalius (1514-64, Flemish anatomist) that Claudius Galen's (130-200 ?, Greek physician and writer) anatomy was based on animal dissections, and that human anatomy had to be based on a careful study of human cadavers. By a curious coincidence, Copernicus' *De revolutionibus* offering the new view of the macrocosm and Vesalius' *Fabrica* containing Galen's refutation and many new anatomical discoveries about the microcosm, man's body, appeared in the same year. Vesalius demonstrated

that anatomical truth about man had to be derived from autopsy, i.e., inspection of human bodies, as George Agricola (1490?-1555, German mineralogist) was teaching with regard to mineralogy, and Leonhard Fuchs (1501-66, German botanist) and others with regard to botany. Text and illustrations of the *Fabrica* view the body realistically in contrast to its former schematic representations.

The metaphor implicit in the above passage is clear: Ptolemy and Galen being products of their age laid emphasis on description. However the inherent contradictions in such a method came to the fore during the succeeding generations. Out of such "rubble" rose Copernicus and Vesalius to restore order in astronomy and anatomy respectively. It was an age of the pioneers of modern science.

What do Copernicus and Vesalius represent or symbolize? They shifted the emphasis from description to discernment, from the concrete to the abstract or from the *scheme* to the *theme*. The new science had entered the scene.

In the same book writing on "Tradition in Science" Werner Heisenberg (1901-76, German physicist who gave us the *Uncertainty Principle*) observes :

When we celebrate the 500th birthday of Copernicus, we do it because we believe that our present science is connected with his work ; the direction he had chosen for his research in astronomy still determines to some extent the scientific work of our time. We are convinced that our present problems, our methods, our scientific concepts are at least partly the result of a scientific tradition that accompanies or leads the way of science through the centuries.

Copernicus the end-product of a long tradition gave it a revolutionary turn. The heliocentric model he bequeathed to posterity was the offspring of the happy marriage of observational data and mathematical rigour. To understand what it means, consider the following elementary problem :

Place a paisa on the 1st small square of the chess board, 2 paises on the second, 4 paises on the third, and so on, till the sixtyfourth small square. (Note that the amount in any square starting from the second is *just* double the amount in the previous) what is the total amount?

(a) Descriptive way : $1 + 2 + 4 + 8 + 16 + 32 + \dots$ upto the sixty fourth term. (Please have a try !)

(b) Mathematical way : $1 + 2 + 2^2 + 2^3 + \dots + 2^{63} = (2^{64} - 1)$ paises.

In terms of rupees it works out to approximately 18,320,000,000,000,000,000. or Rs 18.32 billion-billion !

The descriptive is superficial while the mathematical takes you to the core of the problem. Copernicus' was essentially a mathematical approach : he extracted the hidden pattern out of a heap of apparently disconnected data. In the heliocentric or the Copernican model the sun is at the centre of the universe, surrounded by the planets in circular orbits. In the ascending order of distances from the sun they are Mercury, Venus, Earth, Mars, Jupiter, and Saturn. The stellar dome serves as the fixed backdrop.

Copernicus arrived at this simple and workable proposition through mathematical reasoning : by establishing correlation between reality and data.

Now, this is precisely the essence of the scientific method. The lifetime lasting work of Copernicus has rightly earned him the distinction as the originator of modern science and the scientific method.

What a giant leap it was from the geocentric to the heliocentric, and what a fall was there for man from the pivotal position as the fixed centre of the dynamic universe to the ordinary planetary role ! The

physical/scientific transition took some 2000 years. But the psychological/intellectual transition continues to elude man even today. Moral ? There is no short/quick cut to success, and even when you arrive at success, you are not sure whether it is real or a mirage. Universe does not respect human efforts, pain or time. And this jump from pre-Aristotelian times to the Copernican era was equivalent to a paradigm shift in the human psyche : instead of *I* as then, it is now *thee* or *thou*.

Einstein, a revolutionary of Copernican dimensions, gave the following message on the occasion of the 510th death anniversary of Copernicus (1953) :

We are honoring today with joy and gratitude, the memory of a man who, more than almost anyone else, contributed to the liberation of the mind from the chains of clerical and scientific dominance in the occident . . . A rare independence of thought and intuition as well as a mastery of the astronomical facts, not easily accessible those days, were necessary to expound the superiority of the heliocentric conception conveniently. This great accomplishment of Copernicus not only paved the way to modern astronomy ; it also helped to bring about a decisive change in man's attitude toward the cosmos. Once it was recognized that the earth was not the centre of the world, but only one of the smaller planets, the illusion of the central significance of man himself became untenable. Hence, Copernicus, through his work and the greatness of his personality, taught man to be modest . . .

In retrospect, the geocentric hypothesis attained the status of a theory as it had passed the crucial observational test available at that time. Every theory, however satisfactory in explaining the given data with hints at future developments, is but an approximation to the real state of affairs. In other words no theory is permanent. So was the geocentric theory. It developed cracks beyond repairs. Naturally it had to be discarded. The heliocentric theory based

on sound mathematical data and convincing logic came to the centre-stage. Why this stamp of mathematics ?

Einstein has the explanation :

One reason why mathematics enjoys special esteem, above all other sciences, is that its propositions are absolutely certain and indisputable, while those of all other sciences are to some extent debatable and in constant danger of being overthrown by newly discovered facts . . . there is another reason for the high repute of mathematics, in that it is mathematics which affords the exact natural sciences a certain measure of certainty, to which without mathematics they could not attain. At this point an enigma presents itself which in all ages has agitated inquiring minds. How can it be that mathematics, being after all a product of human thought which is independent of experience, is so admirably appropriate to the objects of reality ? Is human reason, then, without experience, merely by taking thought, able to fathom the properties of real things ? In my opinion the answer to this question is, briefly, this : as far as the propositions of mathematics refer to reality, they are not certain ; and as far as they are certain, they do not refer to reality.

With the advantage of hindsight we can say that Copernicus was on the right track towards a mathematically sound and observationally correct theory. Even then it was flawed ! That the planets revolve around the sun is all right, but the orbits are circular or the sun is at the centre wrong.

Johannes Kepler (1571-1630), single-handed but mathematically armed, waded through a jungle of observational data and set the Copernican system on the right track. But he did not hit the bull's eye straight. Kepler asked himself a few 'pertinent' questions and went on searching for their answers.

What is the intention of the Creator in placing only 6 planets in the solar system ? *Why* are they distributed at such odd intervals with reference to the sun ? *Can* I find any pattern in them ?

Kepler was an ardently God-fearing person with a religious bent of mind. He was the product of a tradition that had unquestioningly *accepted* God as a mathematician par excellence. God had sculpted the universe in accordance with a mathematical plan and thrown the challenge to man to unravel the mysteries of creation.

He had a sharp intellect and a keen insight. As such he could handpick the core of a problem out of a heap of details. Naturally he first looked for some mathematical clues or patterns in God's mosaic. The number 6 came in handy. Is it not the divine number ordained in the *Genesis* ? "And God saw everything that he had made, and behold *it* was very good. And the evening and the morning were the *sixth* day. Thus the heavens and the earth were finished, and all the host of them. And on the *seventh* day, God ended his work . . . and rested" (emphasis added).

Perfection is the hallmark of Almighty's creation, argued Kepler. The number 6 is the immediate example : All its factors add and multiply upto it : $6 = 1 + 2 + 3 = 1 \times 2 \times 3$. There is no other number having this property. (Do you say 28 ? Its factors do not multiply upto it.) He got yet another 'divine' justification in support of the number 6.

Plane-faced convex solids are called polyhedra. Tetrahedron (4 faces), pentahedron (5), hexahedron (6) etc are examples. No upper limit to the number of faces. A polyhedron in which all the faces are identical (or congruent), and the angles between the adjacent faces are equal is called a regular polyhedron. There are only 5 of them ; they are the platonic solids. Because they play an eminent role in Plato's (BC 427? - 347) natural philosophy. The platonic solids are the regular tetrahedron (4), cube (regular hexahedron)

(6), regular octahedron (8), regular dodecahedron (12) and the regular icosohedron (20).

“Plato, in the dialogue *Timaeus*, associates the regular pyramid, octahedron, cube, icosohedron with the four elements fire, air, earth and water (in this order) while in the pentagondodecahedron (12) he sees in some sense the image of the universe as a whole” (Herman Weyl in *Symmetry*).

A Platonic solid admits or takes both the insphere (the inscribed sphere that touches all its faces) and the circumsphere (the circumscribed sphere that contains all the vertices)—in the former case the polyhedron encloses the insphere and in the latter case the circumsphere encloses the polyhedron. No other polyhedron has these ‘divine’ properties—to enclose and to be enclosed.

Kepler’s imagination soared. He made different sized hollow platonic solids, and arranged them in such a way that the circumsphere of the smallest solid is the insphere of a larger one ; again, the circumsphere of this larger solid is the insphere of the next larger one ; and so on. In this way he obtained 5 concentric spheres. Finally the imbedded smallest solid has its insphere concentric with the rest. Kepler visualized the sun at the centre, and the orbits of the 6 planets lying one each on the 6 spheres. If this is a true replica of the solar system then the radii of the spheres should be proportional to the planetary distances from the sun.

There are 120 different models. Which of these will fit into reality ? Poor and hungry Kepler, not always in good health and with a large family to feed, had to toy and toil with his pet idea for years together. Finally success smiled on him (alas ! it was only short-lived as we will see presently—you can’t fit God

to a pet model !): from the centre outwards the regular octahedron, icosohedron, dodecahedron, tetrahedron and hexahedron (cube). The radii of the respective spheres as calculated by him compared not unfavourably with the planetary distances :

| Name of the Planet | Radii of the orbit | |
|--------------------|--------------------|--------|
| | Kepler's model | Actual |
| Mercury | 0.4586 | 0.387 |
| Venus | 0.7945 | 0.723 |
| Earth | 1 | 1 |
| Mars | 1.584 | 1.524 |
| Jupiter | 4.753 | 5.203 |
| Saturn | 8.233 | 9.555 |

The coincidence, approximate though, is remarkable. A scientist obsessed with his prowess and possessed by a problem can somehow establish a one-one correspondence between his pet theory and reality. So did Kepler; even at the first shimmer of the solution his joy knew no bounds. He wrote (1595) :

The intense pleasure I have received from this discovery can never be told in words. I regretted no more the time wasted ; I tired of no labour ; I shunned no toil of reckoning days and nights spent in calculation, until I could see whether my hypothesis would agree with the orbits of Copernicus, or whether my joy was to vanish into air.

Kepler published his speculations in the book *Mysterium Cosmographicum* (*Mysterious Universe*) in 1597. Poor man he had borne the printing charges. He was so sure he had read the "Lord's cards" that he plunged immediately to the next phase of investigation.

Who drives the planets along their orbits ? *Where* to locate him ? *How* to reckon the motions of the planets ? *When* did it start ?

Those were the days when people surmised that

angels carried the planets and the moon around the sun, the flight of birds nearer home was a familiar picture. Perhaps the sun is 'flying these kites', the planets, with the help of invisible strings? Now, your imagination cannot greatly excel your experience, because the latter is the take-off board for speculation to soar high and explore the unknown. Mere speculations, however, would not carry him far, realized Kepler. He was in critical need of observational data to support his deep investigation and mathematical quest.

History, for reasons never explainable by man, had invested this facility—collected and collated astronomical data—in Tycho Brahe (1546-1601), a senior contemporary of Kepler. Tycho was a meticulous observer of the sky, a careful recorder of the findings, and a jealous guardian of the data. Kepler being aware of Tycho's goldmine, wrote to him seeking his helping hand. Tycho had earlier seen the *Mysterium* and had at once gauged the high mathematical calibre of the author.

The reply was as reassuring as the request was invoking: "Come not as a stranger," wrote Tycho, "but as a welcome friend; come and share in my observations with such instruments as I have with me, and as a dearly beloved associate."

The details about the human drama—of love and hate, suspicion and revelation, possession and obsession—need no elaboration here. Oliver Lodge in his illuminating essay *Johann Kepler* puts them succinctly thus:

It is difficult to imagine a stronger contrast between two men engaged in the same branch of science than exists between Tycho Brahe . . . and Kepler . . . The one, rich, noble, vigorous, passionate, strong in mechanical ingenuity and experimental

skill, but not above the average in theoretical and mathematical power. The other, poor sickly, devoid of experimental gifts and unfitted by nature for accurate observation, but strong almost beyond competition in speculative subtlety and innate mathematical perception. The one is the complement of the other ; and from the fact of their following each other so closely arose the most surprising benefits to science.

Soon Kepler realized painfully that his physical (or was it mathematical ?) model of concentric platonic solids with its in- and circum-spheres had to be simply abandoned. You cannot bind "God" in mathematical chains ! Kepler had to start *ab initio* drawing sustenance from Tycho's well maintained and upto-date databank. He was to be the key to the locked casket of Tycho. No doubt Kepler's temporary "joy was to vanish into air" but he was heading towards a more substantial transcendental joy.

During the period 1600-18 Kepler worked mathematically on Tycho's data, extracted the laws of planetary motion, and enunciated them in simple, elegant terms.

Kepler's laws of planetary motion :

1. The orbit of each planet is an ellipse with the sun at a focus.
2. The line joining the planet to the sun sweeps out equal areas in equal times.
3. The square of the period of the planet is proportional to the cube of its mean distance from the sun.

The first one defines the sun-planet link with reference to the fixed stellar background, the second explains the motion of the planet and the third states the relationship between the period—time taken by the planet to complete a revolution around the sun, the "year"—and the average of the sun-planet distances. In short Kepler's laws are the mathematical counterpart of the solar system.

In his magnum opus *Harmonice Mundi*, 1619, Kepler gives his mathematical findings about the solar system. This great work ushered in what we call today the *scientific method*. The author did not explicitly express it as such but the compulsions of the situation—the enigmatic nature versus the heap of data—gradually set him on this *only* course available to understand and interpret nature. About the uniqueness of the method Feynman says :

In general, we look for a new law by the following process. First we guess . . . no ! Don't laugh—it is really true. Then we compute the consequences of the guess to see if this law we guessed is right—what it would imply. Then we compare those computation results to nature—or, we say, to experiment or experience —we compare it directly with observation to see if it works. If it disagrees with experiment, it's wrong. In that simple statement is the key to science. It doesn't make how beautiful the guess-ess, it doesn't make any difference how smart you are—who made the guess, or what his name is. If it disagrees with experiment, it's wrong. That's all there is to it.

Compare this statement with Einstein's on page 36.

13. Significance of the Scientific Method

Oliver Lodge (cited earlier) brings out the significance of the scientific method cogently by drawing our attention to a current (20th century) problem :

To realize what he (Kepler) did for astronomy, it is necessary for us now to consider some science still in its infancy. Astronomy is so clear and so thoroughly explored now, that it is difficult to put oneself into a contemporary attitude. But take some other science still barely developed : meteorology for instance. The science of the weather, the succession of the winds and rain, sunshine and frost, clouds and fog, is now very much in the condition of astronomy before Kepler . . .

Observation is heaped on observation ; tables are compiled ; volumes are filled with data ; the hours of sunshine are recorded, the fall of rain, the moisture in the air, the kinds of clouds, the temperature—millions of facts ; but where is the Kepler to study and brood over them ? Where is the man to spend his life in evolving the beginnings of law and order from the midst of all this chaos ?

And Einstein—

. . . Kepler lived in an age in which the reign of law in nature was yet by no means certain. How great must his faith in the existence of natural law have been to give him the strength to devote decades of hard and patient work to the empirical investigation of planetary motion and the mathematical laws of that motion, entirely on his own, supported by no one and understood by very few ! Our admiration for this splendid man is accompanied by another feeling of admiration and reverence, the object of which is no man, but the mysterious harmony of nature into which we are born. The ancients already devised the lines exhibiting the simplest conceivable form of regularity. Among these next to the straight line and the circle, the most important were the ellipse and the hyperbola. We see the last two embodied—at least very nearly so—in the orbits of the heavenly bodies.

The roles of observation, experiment, intellect and intuition in the scientific inquiry are neatly summed up by Einstein :

It seems the human mind has first to construct forms independently before we can find them in things. Kepler's marvelous achievement is a particularly fine example of the truth that knowledge cannot spring from experience alone but only from the comparison of the inventions of the intellect with observed fact.

In the pursuit of science, the scientific method evolved gradually. What motivates an individual to do science ? Or, why does the human intellect interact with nature ? Henri Poincare (1854-1912) has the explanation :

The scientist does not study nature because it is useful ; he studies it because he delights in it, and he delights in it because

it is beautiful. If nature were not beautiful, it would not be worth knowing, and if nature were not worth knowing, life would not be worth living. Of course I do not here speak of that beauty that strikes the senses, the beauty of qualities and appearances ; not that I undermine such beauty, far from it, but it has nothing to do with science ; I mean that profounder beauty which comes from the harmonious order of the parts, and which a pure intelligence can grasp.

Feynman in his essay *The Making of a Scientist* writes :

I have a friend who's an artist, and he sometimes takes a view which I don't agree with. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree. But then he'll say, "I, as an artist, can see how beautiful a flower is. But you, as a scientist, take it all apart and it becomes dull." I think he's kind of a nutty. First of all, the beauty he sees is available to other people—and to me, too, I believe. Although I might not be quite refined aesthetically as he is, I can appreciate the beauty of a flower. But at the same, time, I see much more in the flower than he sees. I can imagine the cells inside, which also have a beauty. There's beauty not just at the dimension of one centimeter, there's also beauty at a smaller dimension.

In the essay on *The Value of Science* he lists three important ones :

1. The scientific knowledge enables us to do all kinds of things It is an enabling power to do either good or bad—but it does not carry instructions on how to use it. Such power has evident value—even though the power may be neglected by what one does with it. I learned a way of expressing this common human problem on a trip to Honolulu. In a Buddhist temple there, the man in charge explained a little bit about the Buddhist religion for tourists, and then ended his talk by telling them he had something to say them that they would *never* forget and I have never forgotten it. It was a proverb of the Buddhist religion: to every man is given the key to the gates of heaven; the same key opens the gates of hell

2. Another value of science is the fun called intellectual enjoyment

3. The scientist has a lot a experience with ignorance and doubt and uncertainty . . . when a scientist doesn't know the

answer to a problem, he is ignorant. When he has a hunch as to what the result is, he is uncertain. And when he is pretty damn (darn) sure of what the result is going to be, he is still in some doubt. We have found it of paramount importance that in order to progress we must recognize our ignorance and leave room for doubt. Scientific knowledge is a body of statements of varying degrees of certainty—some most unsure, some nearly sure, but none absolutely certain.

The pioneer in human heart transplant Christian Barnard quotes an unknown poet called Sharp :

Is'nt it strange that princes and kings
 And clowns that caper in saw dust rings
 And common people like you and me
 Are builders of eternity ?
 Each is given a bag of tools
 A shapeless mess
 A book of rules
 And each must make as time has flown
 A stumbling block or stepping stone

He adds "I think I did not create a stumbling block but a stepping stone." (Ambujam Anantharaman in *The Hindu*, 12th October 1997)

The significance of the scientific method, then, is to know more and more about nature, imitate it to have fun in the endeavour, to realize one's limitations, and if possible, to make a "stepping stone" as time flows.

14. Scientific Method and Life's Problems

The scientific method is a tool invented by man. Its basic purpose was, and is, to understand the principles governing the natural phenomena, and articulate them in clear, cogent and precise terms. Hence the need for symbols (not the poetic variety, of course), and technical terms which communicate exactly the same idea in all languages—like proper

nouns. For example π is the constant ratio of the circumference of any circle to its diameter ; H_2O is a molecule of water ; g is the acceleration due to gravity while g is the measure of mass, the gram. Silicon, Uranus, Homo Sapiens, amoeba are generally used as proper names in all languages. Thus in science technical terms and phrases are universal while verbal explanations are local.'

Though the method is an evolutionary product of the scientific pursuit, its applications have transcended the field of science. They serve equally well in other activities of life also. The method itself arose while solving the problems posed by nature. Now, extend the meaning of *nature* from the physical world in which we are functioning to cover the very life itself, and its umpteen activities of which science is just one. You have here then a ready tool (*a bag of tools*)—the scientific method—to tackle any issue.

Consider the current, 1997, socioeconomic problem: "Why there is so much poverty amidst so much plenty in India ?" or "Is slum the ugly backlash of affluence?" or "Should misery and luxury coexist ?" or "Is public charity a euphemism for private cruelty?"

Poet William Blake puts it cynically :

Pity would be no more
If we did not make somebody poor
And mercy no more could be
If all were as happy as we

One easy, escapist, irresponsible and certainly diabolical answer to these questions is to point the accusing finger at *karma phala*—an individual is supposed to suffer in the present life for the sins committed by him in the past one.

First, there is only one birth and only one death with one life as the interlink. And such a life cannot

be degraded to a cash book with debit/credit balances carried over to the next life. Secondly, a sedative explanation like *karma phala*, fate or God's will cannot and will not solve the problem. On the other hand there is every likelihood of it promoting inertia and escapism. Finally, a problem arising in the human reference frame has to be tackled in the same context, and not relegated to something nebulous or amorphous.

Adopting the scientific method is the only positive way. The method would require the investigator to define the terms *poverty*, *affluence*, *misery*, *luxury* etc supported by data collected *dispassionately*. Dispassionateness is of crucial importance because we are here dealing with fellow human beings and their interests, and not with inanimate things and their qualities. The latter study belongs to the scientific domain. The course of poverty cuts across all man-erected barriers such as caste, region, politics, language etc. Investigators' personal likes and dislikes have no place here.

One would shudder to look at the objective facts and figures thus assembled. They would reveal not only a much more disturbing state of affairs but would question the very foundations of the society. Siddhartha had to face the negative side of stark reality before becoming the Buddha. Unless one has the moral stamina of the Buddha, a Copernicus or a Gandhi one will continue to find alibis for the misery of the masses.

Maybe a Socrates who had such a compassionate insight and scientific outlook had to fall a victim to his chosen mission. So was Jesus Christ and Mahatma Gandhi. Such "failures" are rather indications of the acuteness of the malignant tumour cor-

roding the society than the inefficacy of the scientific method. Human greed and bigotry are at the base of these “failures.” Yet there is no better weapon available to us to wage war against these unbridled raw emotions than the scientific method.

The method is a tool, not the goal ; a workable plan for action, not the end-product ; and the surest way for analyzing issues and opening before you the real picture. The adjective *scientific* is incidental indicating the origin of the method. However every human problem can be approached with advantage by this tool, a product of the human genius interacting with nature.

The unscientific and barbarous partition of the country, the heinous desecration of the Ayodhya Temple or the later despicable destruction of the Babri Masjid could have been avoided, or at least averted, if the scientific method had been followed instead of the politico-religious gimmick. What great relief such a step would have given to humanity !

It is a fact that life is more comprehensive and complex than science, and as such all the various steps of the scientific method cannot be applied here. Experimental verification may not be possible in several situations. How can you conceive of an adequate foolproof scientific experiment to confirm or deny the existence of emotions benign as well as malignant ? Thus in the context of life we have the counterpart of the scientific method : the *rational* approach. The stress here is on *reason* within the socioethical frame : the greatest good of the greatest number—*bahujana hitāya bahujana sukhāya*. The Buddha has spelt it out more than 2500 years ago :

Believe nothing

Merely because you have been told it

Or because it is traditional
 Or because you yourself have imagined it
 Do not believe what your teacher tells you
 Merely out of respect for the teacher
 But whatever, after due examination and analysis
 You find to be conducive to the good, the benefit
 The welfare of all beings
 That doctrine believe and cling to
 And take it as your guide

True—"The Buddha's attitude towards life is not merely intellectual but practical. It is a realization of that which is good and beneficial. It makes for ethical perfection as well as mental emancipation. This implies a cultivation of good emotions and an abandonment of the bad. The emotional aspect, too, should be developed, though that alone does not lead us to the final goal. Good emotions should always be blended with right understanding, since conduct and wisdom are complementary." (From *The Spectrum of Buddhism* by Piyadassi)

The essence of rationalism is contained in the following *Vachana* of Basavanna, the 12th century saint:

Steal not, kill not, lie not
 Get not angry, dislike not others
 Speak not about thyself, belittle not others' opinions
 This is purity internal and external
 This is the mode to please our Kudala Sangama

15. Scientific Temper

Scientific temper is the state of mind when one is obsessed with and possessed by a problem (*obsession* is an internal urge while *possession* is an external charm). In this state of levitation the *I* or *me* in the person is sublimated to the very *problem* itself. It is objectivity of the highest order. Here the indivi-

dual's personality is incidental inasmuch as he is an instrument governed by the compulsions of the situation. His likes and dislikes have no place. The mind is his, yet not his : *padmapatramivāmbhasa* (*Gita* 5-10). The meaning of the full *śloka* is : "He who acts, abandoning attachments, dedicating his deeds to Brahman, is untainted by sin as a lotus leaf by water." (Swami Chidbhavananda)

Arjuna lakshya (aim) and *Karna ekāgrate* (concentration) are metaphors for this state of mind.

The young prince Arjuna, learning archery under Guru Dronacharya, is asked to set aim to the eye of the dummy bird fixed to the bush-topped tree little distance away.

Guru "What do you see, Arjuna ?"

Sishya "The eye of the bird only."

Guru "What about its body, the surrounding branches of the tree ?"

Sishya "The bird's eye alone exists for me : the eye and I have become one. The rest are nonexistent."

Guru Parasurama rests his head on the lap of his sishya Karna for a nap. Suddenly a wasp dashes in, pierces Karna's thigh and begins to bore it. Blood gushes out causing excruciating pain to him. But the sishya sits statue-still lest the Guru's sleep be disturbed.

Such an enlightened being is called a *sthitaprajna* in *Gita* (2-54 and 56) :

Arjuna asks Krishna—

*sthitaprajnasya kā bhashā samādhisthasya Keshava
sthitadhih kim prabhāsheta kimāsita vrajeta kim*

"What O, Kesava, is the mark of the man of steadfast wisdom, steeped in *samadhi* ? How does the man firm in wisdom speak, how sit, how walk ?"

Krishna replies—

*dukkheshvanudvignamanāh sukhesu vigataspriha
vitarāgabhayakrodhah sthitadhirmuniruchyate*

“He whose mind is not perturbed by adversity, who does not crave for happiness, who is free from fondness, fear and anger is the *muni* of constant wisdom.”
(Swami Chidbhavananda)

The following *sloka* from Shankaracharya’s *Bhaja Govindam* gives the essence of scientific temper in the allegorical form :

*satsangatve nissangatvam
nissangatve nirmohatvam
nirmohatve nischalatattvam
nischalatattve jivanmukthih*

Tune thy mind to the problem (*satsanga*)

Cast off the possessive instincts (*nissanga*)

Develop detachment (*nirmoha*)

See thee now the core of the problem (*nischalatatva*)

And lo ! thou art the solution (*jivanmukthi*)

Nehru Centre, Mumbai, in *A Statement of Scientific Temper* has spelt out the concept thus :

Scientific Temper is neither a collection of knowledge or facts, although it promotes such knowledge ; nor is it rationalism although it promotes rational thinking. It is something more. It is an attitude of mind which calls for a particular outlook and pattern of behaviour. It is of universal applicability and has to permeate through our society as the dominant value system powerfully influencing the way we think and approach our problems—political, social, economic, cultural and educational.

Scientific Temper involves the acceptance, amongst others, of the following premises :

(a) that the method of science provides a viable method of acquiring knowledge ;

(b) that human problems can be understood and solved in terms of knowledge gained through the application of the method of science ;

(c) that the fullest use of the method of science in everyday life and in every aspect of human endeavour from ethics to

politics and economics is essential for ensuring human survival and progress ; and

(d) that one should accept knowledge gained through the application of the method of science as the closest approximation to truth at that time, and question what is incompatible with such knowledge ; and that one should from time to time re-examine the basic foundation of contemporary knowledge.

The method of science, therefore, constitutes a regenerative process for collecting information and processing the collected information to create meaningful patterns leading to an ordered understanding of nature of man himself, his natural and social environment. In this sense, the method of science encompasses all aspects of communicable human knowledge and cuts across all artificial compartmentalization like natural science, social science, applied science etc. The spirit of inquiry and the acceptance of the right to question and be questioned are fundamental to Scientific Temper. It calls upon one to ask the 'how,' the 'what' and the 'why' of an object, event or phenomenon. It further calls upon one to exercise the right to question, provided of course, the questioning of an existing theory, hypothesis, or statement or social situation is done in accordance with the scientific method and is not a bare assertion of one's belief.

Scientific Temper is therefore, incompatible with the acceptance of authorities of all kinds or of 'high priests' who may not be questioned. It leads to the realization that events occur as a result of interplay of understandable and describable natural and social forces and not because someone, however great, so ordained them. These forces are often complex and intertwined and have to be analytically disentangled.

Scientific Temper is compatible with observation and insight, reasoning and intuition, systematic work and creative impulse. It gives rise to an attitude of mind which while being conscious of vast areas of ignorance, is nevertheless, optimistic about human ability to gradually unravel the mysteries that surround us. In this process Scientific Temper becomes a part of the culture, a philosophy, a way of life which leads to the pursuit of truth without prejudice.

Scientific Temper implies the recognition that knowledge often progresses by disproving earlier ideas, beliefs, theories and laws. It considers knowledge as openminded and ever-

evolving. It lays emphasis on verifiability and repeatability, wherever possible, and on the fact that scientific theories, laws and facts allow one to make predictions which can be tested. It recognizes that answers to many questions that may be asked at any given time, may not be available at that time. It, then demands courage and humility to say "I do not know.*"

Scientific Temper calls for recognition of the several major differences between the scientific attitude and metaphysical attitude specially in respect of dogmas proclaimed in the name of religion. There is in fact, essential incompatibility of all dogmas with science. While science is universal, established religions and religious dogmas are divisive. Consider the divisions which exist between Christian, Islamic, Buddhistic and Hindu denominations. Science, in contrast, transcends divisions and is universal. Scientific Temper has a deep emotional content and has, within it, a sense of beauty. That is why considerations based on beauty and simplicity have been often invoked to choose between alternative theories that are otherwise equally tenable.

Inherent in Scientific Temper is a system of value judgements. The inculcation of Scientific Temper in our society would result in our people becoming rational and objective, thereby generating a climate favouring an egalitarian, democratic, secular and universalist outlook. Consequently, Scientific Temper cannot flourish in a grossly inequalitarian society where 50 per cent of the population lives below the poverty line, and almost 70 per cent of our people, especially females, are illiterate. Social justice, widespread education and unrestricted communication are, therefore, prerequisites for spread of Scientific Temper and for optimizing the results of science and technology.

16. Scientific Temper for a Balanced Life

In this chapter I propose to give a resume of the foregoing discussion.

Human life, individually as well as societally, is caged, influenced and shaped by a set of three man-generated forces—*authority, religion and science* act-

* a Johnsonian equivalent of "Ignorance, madam, ignorance"

ing concurrently on it.

Right from birth to death one is subjected to authority of one form or the other—parental, religious, educational, institutional or governmental. There is no escape from it.

One is born into a religion over which one has no control. Whether one wants it or not, religion, caste, colour etc pursue one throughout one's life.

And finally, to eke out one's living one has to depend on science directly or indirectly. Neither authority nor religion can provide the basic necessities of life—food, cloth and shelter. Only science can.

Human life is the creation of natural forces such as atmosphere, gravitation, radiation, environment etc. Man has to shape his life in harmony with them. If he tries to defy or modify them he runs the risk of being fossilized sooner or later.

Not so with man-made forces. When they act in harmony or made to do so, keeping the good of the individual and society as the goal, people are happy and there is all round progress and happiness. The concept of Ramarajya or the egalitarian society is born of such pious hopes. However, reality as revealed in the march of civilization does not appear to have been rosy anywhere any time, except perhaps during the predawn days of evolution of social life. The concept of private property or ownership rights was nonexistent then. Everyone owned everything everywhere, no one individually owned anything anywhere. Why then out of such primordial orderliness and equality the trials and tribulations of the later days arose? The very nature of the forces contains in them the seeds of conflict. If man does not handle the forces with compassion and ethics, always and every-time in the forefront, they will act at cross purposes

resulting in tension and suffering to mankind.

Let us now briefly survey the origin of the forces.

First authority. Even a *sanyāsi* who might have renounced all earthly belongings and retired to holy sequestration, had to be born into a tradition and to undergo the rigmarole of training under the authority of a *Guru*. For the others the all-pervading vise-grip of authority in different forms is too obvious to need further elaboration.

Next, religion. Religious instinct is part of the human psyche. A look at mother nature in all her grandeur and variety, an experience of the ferocity of natural forces as manifested in floods, forest fires or earthquakes, or the routine phenomena of day-night-day parade, the birth-youth-oldage-death cycle, or the observation of the overall order inherent in nature or universe kindle a certain feeling in the individual. The why or how of this feeling is normally beyond his comprehension. He feels some unseen power infinitely superior to him is regulating these activities. By surrendering himself completely to this transcendental intelligence, and by propitiating it appropriately, he thinks, he can lead a peaceful and prosperous life. This is the origin of the religious instinct. It is born out of a feeling of helplessness when man is exposed to the awesome face of nature.

Finally, science. It is the offshoot of man's direct intercourse with earth of which he is but a tiny fragment. His primary needs are food, shelter and clothing. The environment is almost an infinite repository of all these essentials plus more. If man works on it, and with it, in a systematic manner as dictated or required by the natural forces, he is sure to get them. During such experiments, or better, trial-error-trial-partial-success-repetition . . . procedure, he de-

velops a certain rudimentary insight into the working of nature—this is discovery. Such discoveries gradually accrete to form science.

Technology is the handmaid of science. It is applied science, that is the laws of the working of nature, at that. Armed with the knowledge of science man manipulates nature to yield him artefacts and gadgets that go to make his life less hard. This process is invention. Thus we see : nature creates, man discovers the laws of nature, later imitates nature and “re-creates” or invents.

When man first discovered that two hard surfaces rubbed one against the other would produce heat eventually leading to fire he stumbled on science ; and when he constructed the appropriate tools to produce fire through friction he made technology. Both science and technology are creations of the human intellect. Their origin dates back to “in the beginning God created the heaven and the earth.”

The basic characteristics of authority, religion and science are—

Authority commands implicit obedience of its subjects. “Either obey or face the consequences. Do not question.” Physical force is the source of its strength, not reason or logic.

Religion demands total faith (surrender) from its followers. “Have faith in me. I am the saviour.” Karl Marx (1818-83) puts it thus: “Religion is the sigh of the oppressed creature, the heart of the heartless world, just as it is the spirit of spiritless conditions. It is the *opium* of the people.” Resort to supernatural phenomena is an integral part of religion. Initially love and compassion may have motivated it. But soon it gets institutionalized and degenerates into an oppressive force with all its outmoded rituals. More

lives have been and are being lost in religious wars and orgies than in the conventional warfares.

In science there are no commands, demands, *fatwas*, miracles or the supernaturals. Science is an intimate dialogue between man (the created) and nature (the creator) where the response of the former is to be shaped in accordance with the stimulus of the latter. And this stimulus is completely objective, i.e., wholly independent of all human feelings and thoughts. In nature, for every *effect* there is a *cause* and vice versa. Man has to reason out this cause-effect relationship through observation, experimentation, logic and intuition. It is reason, and reason alone, that rules the roost here.

See how they act and react in life. (Extracted from Debiprasad Chattopadhyaya : *Science and Society in Ancient India*, 1979 reprint, pages 201 and 202):

Manu (symbolizing authority) orders "Greet not even by words one who is a logician." (*Manu* iv, 30)

Kathopanishad (symbolizing religion) declares "Not by reasoning (*tarka*) is this wisdom (*mati*) to be attained." (*Kathopanishad* ii, 9)

Carakasamhita (symbolizing science) says : "Any success attained without *mati* (*tarka*) is as good as sheer accidental success." (*Carakasamhita* viii 2.28)

Chattopadhyaya continues :

We have here three clear policy statements on rationalism and logic. The physicians find their therapeutic technique useless if it is not based on reason. The metaphysicians of the upanishads, striving after some supra-rational wisdom of the pure self, express disapproval of the rational approach. The law-giver, convinced of the political utility of implicit faith in Scriptures detests the logician or the rationalist. There is thus something that unites the metaphysician with the law-giver. It is the negative attitude to rationalism or logic, though, while the law-giver simply decrees it, the metaphysician has to seek philosophical grounds justifying his damnation of reasoning.

Authority and religion are subjective forces whereas science is an objective one. Here then lies the root cause for the age-old conflict between them : authority wants religion to echo its dictates, clothe them in mystic language (*rājā pratyaksha devata*—the king is the very incarnation of God) to win over people to its fold and employ science accordingly ; religion assumes superiority over the other two (the protagonists declare that spiritualism is superior to the materialism pursued both in science and authority) ; while science declares that unquestioned authority is anti-man and blind religion is anti-nature, and as such both are redundant—science is compelled to keep pace with the ever changing time, whereas the others if not motivated by lofty and pro-man ideals do not move with time, and so become prisoners of anachronistic do's and don'ts. They become reactionary forces.

In short : authority dictates to obey it ; religion ordains to follow it ; neither authority nor religion has the tool to achieve its respective goals. Here science is compelled to subserve the selfish ambition of the authority-religion combine, and the amorphous common man is the hapless victim of these selfseekers' game plan.

Well, one just cannot wish away the chronic conflict, nor can one do away with the basic forces responsible for it. The golden mean is to harmonize the two powerful subjective forces—authority and religion—with, perhaps, the more powerful and nonsubjective force science. This calls for the greatest harmonizing element, the wisdom of ages to act, react, mediate and enact : *sarvejanāssukhinobhavantu* (may all be happy). Its other name is Scientific Temper.

In the ultimate analysis ethics and compassion are

the basic refrains of a good and contented life. Ethics gives stability while compassion meaning to life. Together, in harmony, they make life complete. Development of Scientific Temper in all our activities at all times is the only sure way to attain this completeness, a sense of achievement and a feeling of fulfilment. When one leads such a noble life, ethics is tempered by compassion, and compassion reined by ethics.

Dhritarashtra was all compassion for his children, the Kouravas, but he was devoid of such a feeling for his nephews, the Pandavas. The balancing and essential element, ethics, was missing in this one-sided affair. Result ? Disaster.

Goutama Rishi was the very embodiment of ethics. However the required humanizing force, compassion, was absent in his conduct with his wife Ahalya. Accursed and petrified, Ahalya lay in stony coldness and sepulchral silence awaiting the arrival of Srirama. The touch of compassion provided by Srirama brought back to the poor lady a life of dignity and honour.

Compassion should not degenerate into nepotism and ethics into rituals. That is why Dhritarashtra is a metaphor for compassion without ethics, and Goutama for ethics without compassion.

After the first nuclear holocaust in 1945, Einstein, the architect of the nuclear energy through his well-known equation $E=mc^2$, expressed his anguish and concern in a letter dated 2nd April 1946 :

I believe that the horrifying deterioration in the ethical conduct of people today stems from the mechanization and dehumanization of our lives—the disastrous by-product of the scientific and technical mentality. Nostra culpa ! Man grows cold faster than the planet he inherits.

There is a popular and oftquoted aphorism by

Einstein :

Science without religion is lame,
religion without science is blind.

In tune with this are the following two aphorisms:

Religion without authority is escapist,
authority without religion is despotic.

Authority without science is imbecile,
science without authority is chaotic.

“Tangle within, tangle without, mankind is entangled in a tangle. I ask this question, Gotama. Who disentangles this tangle?”

“When the wise man well established in virtue (*sheela*) develops concentration (*chitta samādhi*) and wisdom (*panna*), then as a bhikku ardent and prudent, he disentangles this tangle.”

Quoted from *The Spectrum of Buddhism*

The state of mind of such a bhikku is precisely Scientific Temper.

Scientific Temper should be the bedrock of an egalitarian society. It is not a pious hope or a utopian woolgathering. Where religion sets the goal, science paves the way, and authority sets the tone, there flourishes a sound mind in a strong body and smiling environment. That is precisely the dream of Vishwakavi Rabindranath Tagore :

Where the mind is without fear and the head is held high
Where knowledge is free
Where the world has not been broken up into fragments
by narrow domestic walls
Where words come out from the depth of truth
Where tireless striving stretches its arms towards
perfection
Where the clear stream of reason has not lost its
way into the dreary desert sand of dead habit
Where the mind is led forward by thee into everwidening
thought and action
Into that heaven of freedom, my Father,
let my country awake.

17. Astrology—What it is *not*

The following explanations are extracted from Webster's *New Twentieth Century Dictionary* (Unabridged) :

Astrology : Literally, the science or doctrine of the stars, and formerly often used as equivalent to astronomy, but now restricted in meaning to the pseudoscience which claims to foretell the future by studying the supposed influence of the relative positions of the moon, sun, planets and stars on human affairs.

Astronomy : The science which treats of the heavenly bodies—fixed stars, planets, satellites, comets and meteors—their nature, distribution, magnitudes, motions, distances, periods of revolution, eclipses etc.

Pseudoscience : A system of theories, assumptions and methods erroneously regarded as scientific.

Science : A detailed discussion is given in chapter 9.

Superstition : Any belief or attitude that is inconsistent with the known laws of science or with what is generally considered in a particular society as true and rational.

Astrology is the oldest pseudoscience, and faith in it is the oldest superstition. Additionally it is non-science and nonsense too. It is all-pervasive, and its influence, like that of the dreaded disease cancer, is malignant to the mind. That a mind which can probe into the microcosm of an atom and browse in the macrocosm of a galaxy can also build the wind-castle called astrology on no physical or astronomical foundation but only on the gullibility of the ambitious and the cowardice of the meek is a great wonder and disaster. Surely, "ambition should be made of sterner stuff !"

This pseudoscience wears the mask of astronomy

which is a science. Astrology dabbles freely in religious jargon, quotes facilely from ancient (?) texts, handles dexterously modern gadgets and employs nonchalantly the language of science. It spreads its tentacles across the entire society. In this respect it is truly “international” and “inter-personal.”

Even the modern, progressive and the leading daily *The Hindu* should provide good space for the weekly astrological predictions sets one to echo the famous statement from the *Bible* “Ye are the salt of the earth: but if the salt have lost his savour, where with shall it be salted ?” Sample from the issue dated 31st August 1997 :

Sun sign *Cancer* (June 21 to July 20) : Weariness and a sense of unease are likely in your job. Defer new ventures. Father’s health may be affected. Financial stringency likely and you may be forced to take temporary loans. A pleasure trip is likely. Children may suffer setbacks in their studies. Avoid speculation. Though not entirely unfavourable, be cautious in romance.

What is unsaid or unquoted in this hogwash is Scriptural authority to reinforce the blissful vagueness.

Read what 186 “leading scientists including S. Chandrasekhar and 18 other Nobel Prize winners” have to say about astrology (extracted from *Science, Nonscience and Paranormal*. Chief Editor H. Narasimhiah published in 1987 by the Bangalore Science Forum) :

Scientists in a variety of fields have become concerned about the increased acceptance of astrology in many parts of the world. We—the undersigned astronomers, astrophysicists and scientists in other fields—wish to caution the public against the unquestioning acceptance of the predictions and advice given privately and publicly by astrologers. Those who wish to believe in astrology should realize that there is no scientific foundation for its tenets. In ancient times people believed in the predictions

and advice of the astrologers because astrology was part and parcel of their magical world view. They looked upon celestial objects as abodes or omens of the Gods, and thus intimately connected with events here on the earth ; they had no concept of the vast distances from the earth to the planets and stars. Now that distances can be and have been calculated, we can see how infinitesimally small are the gravitational and other effects produced by the distant planets and the far more distant stars. It is simply a mistake to imagine that forces exerted by stars and planets at the moment of birth can in any way shape our future. Neither is it true that the positions of distant heavenly bodies make certain days or periods more favourable to particular kinds of action, or that the sign under which one was born determines one's compatibility or incompatibility with other people.

Why do people believe in astrology ? In these uncertain times many long for the comfort of having guidance in making decisions. They would like to believe in destiny predetermined by astral forces beyond their control. However, we must all face the world, and we must realize that our future lies in ourselves, and not in the stars.

One would imagine in the day of widespread enlightenment and education, that it would be unnecessary to debunk beliefs based on magic and superstition. Yet, acceptance of astrology pervades modern society. We are especially disturbed by the continued uncritical dissemination of astrological charts, forecasts and horoscopes by media and by otherwise reputable newspapers, magazines and book-publishers. This can only contribute to the growth of irrationalism and obscurantism. We believe that the time has come to challenge directly and forcefully, the pretentious claims of astrological charlatans.

It should be apparent that those individuals who continue to have faith in astrology do so in spite of the fact there is no verified scientific basis for their beliefs, and that there is strong evidence to the contrary.

Bart J. Bok
Emeritus Prof.of
Astronomy, Univ.
of Arizona

Lawrence E. Jerome
Science writer
Santa Clara
California

Paul Kurtz
Professor of
Philosophy
SUNNY at Buffalo

Nobel Prize Winners—

1. Hans A. Bethe, Professor Emeritus, Physics, Cornell
 2. Francis Crick, Medical Research Council, Cambridge, Enagland
 3. John Eccles, Distinguished Professor of Physiology and Biophysics, SUNNY at Buffalo
 4. Gerhard Herzberg, Distinguished Research Scientist National Research Council, Canada
 5. Wassily Leontief, Professor of Economics, Harvard Uniniversity
 6. Konrad Lorenz, University Professor, Austrian Academy of Sciences
 7. Andre M. Lwoff, Honorary Professor, Institut Pasteur, Paris
 8. Peter Medawar, Medical Research Council, Middlesex University, England
 9. Robert S. Mulliken, Distinguished Professor of Chemistry, University of Chicago
 10. Linus C. Pauling, Professor of Chemistry, Stanford University
 11. Edward M. Purcel, Gerhard Gade University Professor, Harvard University
 12. Paul A. Samuelson, Professor of Economics, MIT
 13. Julian Schwinger, Professor of Physics, University of California, Los Angeles
 14. Glen T.Seaborg, University Professor, University of California, Berkeley
 15. J. Tinbergen, Professor Emeritus, Rotterdam
 16. N. Tinbergen, Professor of Animal Behaviour, Oxford University
 17. Harold C. Urey, Professor Emeritus, University of California, San Diego
 18. George Wald, Professor of Biology, Harvard University
 19. S. Chandrashekar, Chicago University
- and other 167 Leading scientists

(Published in *The Humanist* in its September/October 1975 issue , USA)

Swami Vivekananda (1863-1902) has this to say on astrology (*Swami Vivekananda's Works*, volume 8, *Man the Maker of his Destiny*) :

There was a very powerful dynasty in Southern India. They made it a rule to take the horoscopes of all the prominent men living from time to time, calculated from the time of their birth. In this way they got a record of leading facts predicted, and compared them afterwards with events as they happened. This was done for a thousand years, until they found certain agreements ; these were generalized and recorded and made into a huge book. The dynasty died out, but the family of astrologers lived and had the book in their possession. It seems possible that this is how astrology came into existence. Excessive attention to the minutiae of astrology is one of the superstitions which has hurt the Hindus very much.

I think the Greeks first took astrology to India and took from the Hindus the science of astronomy and carried it back with them to Europe. Because in India you will find old altars made according to a certain geometrical planes, and certain things had to be done when the stars were in certain positions, therefore I think the Greeks gave the Hindus astrology, and the Hindus gave them astronomy. I have seen some astrologers who predicted wonderful things ; but I have no reason to believe that they predicted them from the stars, or anything of the sort. In many cases it is simply mind-reading. Sometimes wonderful predictions are made, but in many cases it is errant trash

There is an old story of an astrologer who came to a king and said, "You are going to die in six months." The king was frightened out of his wits, and was almost about to die then and there from fear. But his minister was a clever man, and this man told the king that these astrologers are fools. The king would not believe him. So the minister saw no other way to make the king see that they were fools but to invite the astrologer to the palace again. There he asked him if his calculations were correct. The astrologer said that there would not be a mistake, but to satisfy him he went through the whole of the calculations again and then said they were perfectly correct. The king's face became livid. The minister said to the astrologer, "And when do you think you will die?" "In twelve years," was the reply. The minister quickly drew his sword and separated the astrologer's head from the body, and said to the king, "Do you see this liar ? He is dead this moment."

If you want your nation to live, keep away from all these

things. The only test of good things is that they make us strong. Good is life, evil is death.

Despite all facts, logic, observations and rational explanation completely debunking astrology as flotsam why or how does it flourish in an age of science and technology as now ? The reasons are cowardice, fear, anxiety, insecurity, over-ambition, incompetence and immorality. "Cowards die many times before their deaths. The valiant never taste of death but once" (Shakespeare). When one is in fear of one's future or life because of the factors mentioned above one resorts to the surreptitious way of looking into "Lord's cards." Who is to read and interpret them? Thus the astrologer enters the arena with all his pretensions. The fear-stricken naive individual falls an easy prey to the hungry astrologer's questionable means and Machiavellian manoeuvres.

Now, cowardice arises out of lack of faith in one's capacity to face life. Fear is the resultant of the individual's past misdeeds. Anxiety is the reflex action due to fast living. Insecurity arises out of leading an unethical, unsocial or antisocial life. Over-ambition is continually fuelled by inferiority complex. Incompetence and inefficiency go together when a person puts on a larger-than-life countenance. Immorality is the end-product of unbridled craving for success and publicity without the "sterner stuff" needed thereon. Sensuality is an important ingredient of immorality. Acting together they cause neurosis—a fit case for the astrologer to play his deceitful game towards self-aggrandizement.

Did Gandhi ever suffer from such neurosis ? How many Prime Ministers, Chief Ministers of even Army/Police Chiefs could walk like him unprotected amidst the tumultuous and tempestuous masses ?

Man unknowingly and haughtily erects barriers around him for providing security cover against self-created chimera. What happened to Pareekshidraja? Or near our times, to Indira Gandhi and Rajiv Gandhi?

Superstitions provide the necessary raw material for building such artificial constructs. And astrology is the king of superstitions, the most dangerous at that. An ethically sound and compassionate life led in the rational plane tells you : today is the end-product of all yesterdays and the determinant of all tomorrows. The present is the only real thing in your hands, the past has faded into oblivion, and the future is yet to come. It has to be shaped by you with the experience of the past. As you sow today so you reap tomorrow. Astrology negates this simple fact of nature and tells you : your future is shrouded mysteriously in the nine “planets” Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn, Rāhu and Ketu ; their positions at the time of your birth as reflected in the horoscope determine your entire life. It hits at the very taproot of your initiative, the nature-given gift ; it turns or deflects your attention away from genuine work to escapism ; and it breeds in you irrationalism. It is a slow-killing poison.

As a boy of seventeen, Einstein wrote : “A happy man is too satisfied with the present to dwell too much on the future.”

Swami Vivekananda said : “The first thing to be got rid of by him who would be a *Jnāni* is fear. Fear is one of your worst enemies. Next believe in nothing until you *know* it.”

Read the Buddha’s ordainment printed on page 70.

So you would certainly want to know what astrology is.

18. Astrology—What it is ?

Astrology has two distinct incongruous, discordant and incoherent parts : astronomy, future reading.

Incongruity : The findings of astronomy can be tested against nature and accepted if confirmed and rejected if not. *NO* such practical and foolproof testing is possible in foretelling. Faith in astrology (read—the astrologer) is a prerequisite condition. There is, therefore, no harmony between the two.

Discordance : Astronomy is a science. Foretelling (peeping into the “Lord’s cards”) is against natural laws. Therefore this (future-reading) is a deceitful game. Hence non-science. Nature is not a cinema reel in which all the past, present and future events are imprinted and secretly preserved by the Creator (?). That the astrologer through is *divya drishti* or mathematical calculations (?) can steal a look at it for the benefit of the client against a consideration is in total discordance with natural laws.

Incoherence : Astronomy lives in the present and opens itself to future possibilities. The entire history of science bears evidence to it. But the authority for future-reading is buried deep in the mysterious vaults of the bygone past. Evidently the two cannot be logically connected. Yet astrologers maintain that their pet subject is a “statistical science” (a euphemism for unlimited bluff and bluster).

The astronomy part of astrology is just the geocentric (or Ptolemaic) system discussed earlier. The twelve “houses” or “mansions” that you see in that ominous sheet of parchment called the horoscope are just a convenient and workable chart of the Ptolemaic model :

| | | | |
|----|---|---|---|
| 12 | 1 | 2 | 3 |
| 11 | | | 4 |
| 10 | | | 5 |
| 9 | 8 | 7 | 6 |

The twelve small squares 1 to 12 are the mansions/houses/abodes of the nine celestial wanderers, *nava-grahas*. In the Indain terminology they are the *rāsis*

| | | | |
|------------------|---------------|--------------|--------|
| Pisces | Aries | Tau- raus | Gemini |
| Aqua- rius | | | Cancer |
| Capri- corn | | | Leo |
| Sagitta- rius | Scor- pius | Libra | Virgo |

| | | | |
|-------------|----------------|----------------|----------------|
| Meena | Mesha | Vrisha- bha | Mithu- na |
| Kum- bha | | | Karka- taka |
| Ma- kara | | | Simha |
| Dhanu | Vris- chika | Tula | Kanya |

The nine celestial wanderers are :

| | |
|-----------------|------------------------|
| Surya (Sun) | Sukra (Venus) |
| Chandra (Moon) | Sani (Saturn) |
| Mangala (Mars) | Rāhu (ascending node) |
| Budha (Mercury) | Ketu (descending node) |
| Guru (Jupiter) | |

Why twelve ? And nine ?

When astrology was evolving in the pre-Christian times the recipe for this potion comprised the apparent stellar display *there* and a mixture of experience, mysticism and imagination *here*. Fear of the unknown, and unquestioned faith in the Creator's will together with a luxurious sprinkling of occult produced the monstrosity called astrology.

What the ancient man saw he accepted as true and proceeded to give descriptive meaning to it. What he did not see he imagined and developed a 'theory' which at best could be read as a make-believe narrative of the celestial phenomenon.

And what did he see ? But not perceive ?

1. The seasons were repeating regularly. During one such cycle or period, called the year, there were approximately 12 full/new moons. Nearly 360 days made one year. Hence the prominence to the number twelve—recognition of a natural fact. Thus came into circulation the 12 zodiacal constellations Aries through Pisces reckoned in the west-east direction. The number 360 is reflected in the circle with its 360° at the centre. There is no divinity nor demonism hidden in these or other numbers.

2. They saw 7 wanderers (hence the name planets) confined to a narrow stellar belt called the zodiac (rāsichakra) : Saturn, Jupiter, Mars, Sun, Venus, Mercury, and Moon. Additionally they noticed that the 'ominous' and evil-portending (?) eclipses occurred only when the Sun and the Moon were in the vicinity of two diametrically opposite points with respect to man. Though no physical objects could be located at those eclipse-prone or eclipsing points, the observed fact could not be overlooked. So the primitive skygazers placed two invisible demons there who were supposed to swallow the Sun during a solar eclipse or the Moon during a lunar one. These are the nodes—Rāhu, the ascending node, and Ketu, the descending node. These invisible demons are also 'inhabitants' of the zodiac. This in short is the origin of the nine-planet or *navagraha* concept—seven are concrete, two are imaginary.

3. The periodicity of the 9 planets were accurately

determined by observation and their changing positions and relative orientations marked. The 12 *rāshis* or the zodiacal constellations mentioned earlier came in handy for this primitive logical thinking.

4. A certain link between seasons, weather changes and other terrestrial phenomena and the positions of the 9 planets was perceived. While the Sun and Moon definitely control the weather conditions on earth, no such thing—not even any gravitational effect—is perceptible with regard to the remaining wandering objects. Yet the primitive astronomers thought otherwise. For instance, it is just one of those apparent coincidences that, when the Sun ‘enters’ *Mrigasira* group of stars in between Taurus and Gemini, the rainy season starts. It gets intensified as the sun moves on to Betelgeuse (*Ādrā*). So they surmised, wrongly of course, these stars control the monsoon—an example for synecdoche. Unfortunately the physical universe cannot be explained away through figures of speech. Consider the star Betelgeuse some 520 light-years ($1 \text{ light-year} = 365.2422 \times 24 \times 3600 \times 300,000 \text{ km} = 9.47 \times 10^{12} \text{ km}$) away from us controlling physically the clouds surrounding us ! By contrast the Sun is just 8.7 light-minutes away from us—our nearest and our personal star—and the Moon, though tiny (some 65 moons can be packed inside the earth), close at some 1.3 light-seconds, have perceptible gravitational effect on the earth as a whole (and *not* on any single individual). Coincidences and analogies may serve as illustrations to clarify a knotty issue. But they are not scientific proofs explaining reality logically and experimentally.

5. The Moon’s motion is easily discernible on a daily basis. The continuously changing phases—waxing during the bright fortnight (*sukla paksha*) and wan-

ing during the dark fortnight (*krishna paksha*)—are both a source of joy and education to watch. The moon takes 27.3 days to complete a revolution with reference to the fixed stars. Hence the number 27, and as many stars along the lunar orbit confined to the zodiac got importance. The concept of *nityanakshatras* (moon's daily abodes) has arisen thus. Ashwini (Hamal) through Revati (Epsilon Pisces) are the names of the 'bivouacs' or 'ports' of this eternal traveller or cruiser. The Moon is our nearest celestial neighbour and our only satellite. For obvious psychological reasons it has become man's personal friend and guide. The moonlore is aplenty in all civilizations. All this is to be read as literature—fanciful flights of unbridled imagination—and not as science. If lovers are moon-struck and lunatics are mooncrazy, the reasons are to be looked for here on the terra firma and not adduced to the starry heavens.

Nevertheless the linking of celestial phenomena with the terrestrial events and human affairs developed gradually into a delicate fine art. It was supported and reinforced by the finesse of mathematical calculations. Mathematics with its hieroglyphical symbols and signs are the very words of God in the eyes of the uninitiated majority. Thus was born the horoscope, a hybrid progeny of the unhappy marriage of astronomy to human fright and flight. Fright—about the unknown future. Flight—cowardice in meeting the present harsh reality of life.

A child is born. Astronomically speaking it means the place (latitude and longitude) and the time are known. The face of the heavens at that moment—the orientation of the zodiac and the relative places of the 'planets' in it—can be calculated and depicted in a well-evolved chart called the horoscope. One can veri-

fy it with the *apparent picture* of the sky.

Today any mathematical calculation implies the employment of the computer. It is a *dead* machine which does calculations and other drudgery as instructed by the *living* and *knowledgeable* human beings commanding it. It is just a tool of science. But what it does, need not be always science. Therefore the heavy dependence on the computer for preparing the horoscopes and forecasting by the modern jet-set smart and get-rich-quick astrologers, enjoying the five-star-hotel luxuries, is simply an eyewash to debunk the gullible preys : "Your fear and ignorance are my strength and capital." That is their refrain.

Why *apparent picture* ? The zodiacal or other constellations that seem to ceil the dome above us have *no physical existence*. They are illusions affecting all of us. Thus the sun in the house of Aries is not the same as an individual seated on a chair. First, the figure Aries or any other constellation (there are 88 well-defined constellations completing the jigsaw puzzle called the celestial sphere) has no physical existence—the individual stars making it are far and wide apart and in eternal motion with varying speeds in different directions ; yet because of the largeness of the universe and the microscopical smallness of man in spacetime the constellations (i.e., the apparent figures) appear fixed.

And secondly "Sun in the house of Aries" simply means we see the Sun in the foreheavens of Aries. The physical separations of the individual stars vis-a-vis the sun may run to several hundreds of light-years. Thus what we see is a universal hallucination, a make-believe of our own creation. On such unreal foundations and fictitious premises rests astrology, the greatest hoax man has ever invented to fool

himself.

Here are two horoscopes/charts one for a solar eclipse day and the other for a lunar eclipse day.

| | | | |
|----|------------|----------|----|
| | K | | |
| Sa | 24-10-1995 | | |
| | | | |
| | Ma J | SM KV | Me |

| | | | |
|----|------------|---------|----------|
| Sa | | | |
| MK | 16-09-1997 | | |
| J | | | SMe R |
| | | Ma V | |

S-Sun, M-Moon, Ma-Mars, Me-Mercury, J-Jupiter, V-Venus,
Sa-Saturn, R-Rahu, K-Ketu

Such charts/horoscopes can be cast for every second past, present and future. That is because celestial mechanics is a science, and as such the necessary software can be written into a computer. There is nothing divine or superhuman about this mechanical, today computerized, rigmarole. Finer details because of the place and instant of birth can also be integrated into this broad frame. So far it is science.

Now let us consider what Swami Vivekananda has said in his talk quoted on page 87-88 : "There was..... very much." Assume that in this computer-age a large number of babies born all over the globe are computer-collared (akin to radio-collaring the tigers for studying their movements, living habits etc) or at least their development records are maintained in computers in a set pattern. So there you have, in due course, several individuals and their computer records. The horoscope is one such record.

Out of a random heap of several hundreds of such horoscopes can you sieve out or decant any pattern the way Kepler did with the jungle of data provided

by Tycho ? For instance consider the Mars-in-the-eleventh-house (*Kumbha*) horoscopes. Suppose a majority of the corresponding individuals are suffering from a common disease can you not, therefore, conclude that there is a subterranean subtle cause-effect relationship between the two : Mars in the eleventh house and this particular illness ? Again if a majority of the ninth-house-Jupiter persons become fabulously rich over a period, the unambiguous connection between Jupiter, Dhanu and wealth can be inferred ? Here, then, you have a ‘scientific way’ to extract the laws of human destiny out of the existing horoscopes. Further these laws are verified and confirmed in each of the cases. So there is, after all, some science in astrology ! Let me categorically state that mere application of the scientific method (which is just a useful tool) to *any* issue does not ipso facto confirm scientism in it.

Did the authors of the “ancient, holy divine and what not” tomes on astrology the world over, including the *Prophecies of Notstradamus* have the facilities of computers, laboratories etc ? What a silly irrelevant and irreverent question ! These sacred works contain the inspired sayings of divine seers of yore. They were *trikālajnānis*, who could see and read the past, present and future of all mankind. Read the first two quatrains from *The Final Prophecies of Nostradamus*, (Erika Cheetam) :

I.I. Sitting alone at night in secret study, it rests solitary on the brass tripod. A slight flame comes out of the emptiness, making successful that which would have been in vain.

I.II. The wand in the hand is placed in the middle of the legs of the tripod. He sprinkles with water both the hem of the garment and its (his) foot. Fear, a voice runs trembling through the sleeves (of his robe.) Divine splendour ; the God sits nearby.

Out of such shibboleth have sprung the *Nostradamus* volumes claiming “the best selling sequence.” And out of similar mucky mumbo jumbo the viral disease of astrolgoy is born.

Ancientness and tongue-twisting names, emphatic assertions, or divine incantations in a babble is no guarantee to the authenticity of astrology.

Quite imperceptibly we have now come to the second part of astrology : forecasting, foretelling, prediction or future-reading. Here horoscope is the launching pad. Ancient works in which are enshrined the future of every individual, as the astrologers claim, are the reference points. If you or I read them nothing except a feeling of mystic nothingness yawns at us ! An immediate example is the Nostradamus quatrains quoted above. But the astrologer is eminently clever in this deceitful game. Is he not divinely ordained to interpret (euphemism for unlimited bluster and unashamed skulduggery) the sacred *mantras* ? What the spider does on its unsuspecting prey, the astrologer repeats on his simple catch but with greater competence and finesse. Brainwashing allusions, unnerving calculations, frightening hints, enticing promises are all parts of the trickery. Only the weak and the meek go to the astrologer while the strong and the brave face the problems of life.

Can the strologer alter the course of a planet
by manipulating the horoscope ?

Natural laws determine its run

Facing life irrespective of the planetary
aspect is the only way

Patience the best armour Mankutimma

—*Mankutimmana Kagga* by D. V. Gundappa

19. Time—Good or Bad ?

One of the surest weapons in the arsenal of the astrologer is the irrational division of time and days/months as good or bad. Time is a feeling arising in the human mind because of the passage of events. The events in themselves have no “mind” or “heart” and as such to classify them as good or bad, amounts to imputing human intentions to nature.

Time is the interval between two events. The feeling you get, say, between two consecutive sunrises is the passage of “time.” It is called a day. For the sake of convenience, a day is divided arbitrarily into 24 hours, an hour into 60 minutes and a minute into 60 seconds. Further subdivisions are done as and when needed in advanced scientific calculations. Inspiration for the numbers 24 and 60 is derived from nature: there are nearly 24 fortnights in a year and there are approximately 60 days in two months. Also 360, the approximate number of days in a year, is a multiple of 60.

Time, like space and velocity, is a measurable physical quantity : you move (*velocity*) in *space* during which process *time* elapses. Even a child knows by experience

$$[\text{velocity}] \times [\text{time}] = [\text{space}]$$

No velocity → no movement → no time →
no space → no velocity !

The velocity-time-space relationship is a fundamental property of nature. In civilian terms, time is nature’s language indicating the eternal progress of events. Figuratively speaking, time paints history on the canvas of space, or space dances to the tune of time.

There is nothing like *good* or *bad* time. Nature is

not a signaller waving green approving your move and red disapproving it. So people who believe in Rāhukala and such other gibberish as inauspicious should turn inward and ensure that their mental health is sound. It is again because of lack of selfconfidence and a fear about the unknown that such superstition arises in the mind. Of course it is continuously fuelled and fanned by the fellows- in-distress and the vested interests.

The corresponding superstition with regard to space is Vāstu, the illegitimate child of structural engineering, astrology and a host of similar tomfoolery . The core idea of Vāstu is : some structures in a house by their location and interrelationship with others are harmful to the occupants ; and the evil effects can be rectified by suitably altering them *as per the advice* of the Vāstu expert ! Yet another case of selfdeception and intellectual bankruptcy usurping the place of science.

Now about the day. It is the smallest natural unit of time. The next unit is a fortnight, approximately 14 days. Then the month with nearly 30 days and finally the year having 365.2422 days or 12 months or 24 fortnights. Lot of mathematical finetuning has gone into these units but that is of no relevance for the present discussion.

The Babylonian astronomer-philosophers of Chaldea (on the banks of Euphates river and Persian Gulf) gave us the 24-hour day and the 7-day week. It was necessitated by a practical need—man can grasp ideas, traverse distances or eat food in small quanta as prescribed by nature. You can't bite more than you can chew ! This is true of time too.

Now of the two naturally available units of time the day is too short and frequent while the fortnight is

too long for reckoning the amount of physical labour. Here came in handy the number 7 : there are 7 messengers of God, Sun through Saturn in the sky ; also 7 is one-half the number of days in a fortnight. Thus arose the 7-day week concept. Regarding the division of the day, 24 was a convenient “God-gifted” number. Thus we got the 24-hour day.

How to name the 7 days in a week ? Of course the 7 celestial Gods are there very much eager to lend their names (so surmised the primitive philosopher. One sees the world through one’s eyes, and the eyes see what the mind desires). But, in what order out of the possible 720 combinations ?

Through time-consuming observation and painstaking collation, they arrived at the final figures regarding the *periods* of the 7 ‘planets’ (pages 42, 49). They were arranged in the descending order of their periods of revolution. Perhaps the low profile slowness of Saturn aroused some mystical feelings about it—hence it got the first place. The unattainable has a greater attraction than the attainable. The arrangement thus arrived at was :

Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon

Now comes the leap of intuition. Divide the day into 24 hours as shown in the figure. Allot the slot number 1 to any ‘planet’ of your choice. Follow the two conditions: the day shall be called by the name of the ‘planet’ in the first slot ; the remaining slots will be filled up by the ‘planets’ as per the above arrangement.



For instance let us allot slot number 1 to Mars. Then today shall be called Tuesday. The succeeding slots are to be filled as follows :

| | | | | | |
|---------|-----|---|----|----|----|
| Mars | ... | 1 | 8 | 15 | 22 |
| Sun | ... | 2 | 9 | 16 | 23 |
| Venus | ... | 3 | 10 | 17 | 24 |
| Mercury | ... | 4 | 11 | 18 | 25 |
| Moon | ... | 5 | 12 | 19 | |
| Saturn | ... | 6 | 13 | 20 | |
| Jupiter | ... | 7 | 14 | 21 | |

The 25th hour slot of today (Tuesday) goes to Mercury. Now, today's 25th hour is tomorrow's 1st hour. Thus tomorrow shall be named after Mercury—Wednesday. You can complete the cycle in the same way and see Thursday, Friday, Saturday, Sunday and Monday coming in this order and opening out the next week with Tuesday again.

This is the system of reckoning now in vogue throughout the globe. We accept it as natural and bestow no thought on it. However it is important to remember that this system is artificial, a man-invented arrangement. The sky or the natural environment around you do not give any hint about the name of the day. But with reference to daytime, nighttime, full moon etc nature indicates those events.

Therefore to classify days or moments as auspicious or inauspicious is irrational, antinature and as such superstitious. Belief and faith are necessary for life. 'Belief' is accepting something without questioning, and 'faith' is the steadfastness with which one sticks to one's belief. Our beliefs and faith are to be based on the wisdom of ages and not on hearsay.

May not "this goodly frame, the earth" seem to you "a sterile promontory"; may not "this most excellent canopy the air, look you, this brave o'erhanging firma-

ment this majestical roof fretted with golden fire” appear to you “no other thing . . . than a foul and pestilent congregaion of vapours.”

“What a piece of work is a man ! How noble in reason ! how infinite in faculties ! in form and moving, how express and admirable ! in action, how like an angel ! in apprehension, how like a god ! the beauty of the world ! the paragon of animals !”

The only method—a gift of nature—available to us for rising to our fullest potential and leading a happy life in a cooperative commonwealth of nations is the cultivation and practice of Scientific Temper in all walks of life irrespective of our vocations. If not “And yet, to me, what is this quintessence of dust ?” (Quotations from *Hamlet*)

20. It pays to Remember

Agnosticism : belief that it is not possible to say definitely whether or not there is a God.

Atheism : belief that there is no God.

Fanaticism : the obsession that *my* religion alone should exist in the world, all other religions are to be destroyed, and that in all matters of dispute the religious dictate shall be final.

Fundamentalism : the obsession that in all human matters the religious dictate shall be final. A fanatic is more dangerous to the society than a fundamentalist. The stands of both are anti-nature and hence anti-human.

God : any of various beings conceived of as supernatural, immortal and having special powers over the lives and affairs of the people and the course of nature. “God is the finest invention of the human mind.”

Rationalism : the belief that your life should be based on reason and logic, rather than emotions or religious beliefs.

Religion : belief in a God or Gods and the activities that are connected with this belief, such as prayer or worship in a temple etc.

Science : the study of nature and behaviour of natural things and the knowledge that we obtain about them.

Secularism : a system of social organization and education where religion is not allowed to play a part in civil affairs.

Theism : Swami Vivekananda explains theism as—
Belief in the existence of God. The awakening of the soul to its bondage and its effort to stand up and assert itself— this is called life. The eventual triumph, when all the slavery is blown away, is called salvation, *Nirvāna*, freedom. Everything in the universe is struggling for liberty. When I am bound by nature, by name and fame, by time, space and causality, I do not know what I truly am. But even in this bondage my real self is not completely lost. I strain against the bonds ; one by one they break, and I become conscious of my innate grandeur. Then comes complete liberation. I attain to the clearest and fullest consciousness of myself—I know that I am the infinite spirit, the master of nature, not its slave. Beyond all differentiation and combination, beyond space, time and causation, I am that I am.

In conclusion let me say : If belief in God makes you a better human being I respect *your* God because of you. But for that reason I do not need a God to preside over the activities of man. If non-belief in God makes you a worse human being I have no respect for you or your belief. Belief and faith should nurture man's initiative for better social purposes.

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2. Humility (*anahamkara*). The recognition that the scientific pursuit contains in itself the destruction of the old and unworkable, the creation of the new and the useful, and the wisdom to know the difference between them.

3. Experimentation and innovation (*swatantra-nveshana*). Testing the theory against reality.

4. Relentlessness (*nirdakshinya*). The scientists' work is never done.

5. Integrity (*arjavam*). You cannot cheat Nature; you can only fool yourself.

6. Creativity (*pratibha*). The seeing of things as they really are, the flash of lightning that illuminates the lay of the land, the incredible that with the flux of time appears as the inevitable.

"I have talked about these six elements of the temper of science as if they are distinct things. But that, too, is a partial picture and to that extent untrue. It really is a six-faced entity, a Shanmukha. Like the mythological Shanmukha it is a lovable thing in one of its aspects ; the giver of refuge and bestower of boons in another aspect, ever shining, ever glorious."

G. T. Narayana Rao (1926) of Madikeri obtained his M. A. (Mathematics) from the University of Madras in 1947, worked as a Lecturer in Mathematics, 1947-69, had a stint with the NCC, 1952-59, on invitation by the University of Mysore worked as Science Editor, Kannada Encyclopaedia, 1969-86, and since retirement at sixty has been writing books on science in Kannada.

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